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ART. XXVI.—*Comparison of the mean daily range of the Magnetic Declination and the number of Auroras observed each year, with the extent of the black spots on the surface of the Sun;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College.

IN a former number of this Journal (Sept., 1870), I instituted a comparison between the mean daily range of the magnetic declination, and the number of auroras observed each year, and also with the extent of the black spots on the surface of the sun. That comparison appeared to me to establish a connection between these three classes of phenomena, and indicated that auroral displays at least in the middle latitudes of Europe and America are subject to the law of periodicity; that their grandest displays are repeated at intervals of about sixty years, and that there are also other fluctuations less distinctly marked which succeed each other at an average interval of about ten or eleven years, the times of maxima corresponding quite remarkably with the maxima of the solar spots.

These conclusions were based upon a combination of the auroral observations made in Europe south of the parallel of 55°, with the observations made at New Haven and Boston. It is of course desirable that conclusions so important should be tested by a comparison with all the materials which we can command; and I therefore improve the opportunity afforded by the publication of a new and very complete catalogue of auroras by Prof. Joseph Lovering. This catalogue is contained in the Memoirs of the American Academy, vol. x.

In comparing the relative extent of the black spots on the surface of the sun, I employ the relative numbers given by Dr. Rudolf Wolf of Zurich. While the correspondence between the fluctuations of the sun's spotted surface, and the range of the magnetic declination is very remarkable; some small discrepancies are noticeable, particularly before the year 1825, when the observations were less numerous and systematic then they have since been; and it has appeared to me that these discrepancies might be at least in part the result of the incompleteness and looseness of the observations themselves. In my former article already referred to, I pointed out certain years for which the relative numbers given by Dr. Wolf appeared to me to rest upon a very uncertain basis. These years were 1793, 1794 and 1795; and also the years 1801 to 1807 inclusive.

In the Vierteljahrsschrift, vol. xvi, pp. 89–99, Dr. Wolf has given in full the materials for these years, and has deduced new values for the relative numbers differing considerably from those which he had before published. For the years 1793, '4 and '5, it appeared to me that Dr. Wolf's relative numbers were too small. Dr. Wolf's new discussion of the observations has led him to increase his relative numbers for each of these years, by an average quantity equal to two-thirds of that which I had proposed, thus admitting the substantial justice of my criticism. It is also noticeable that the observations for the last month of 1794 and the first two months of 1795, furnish very large relative numbers, indicating an unusual activity upon the sun's surface at that time; and this is a fact to which in my former article I desired to call special attention.

For the years 1801–1807, the observations are very few and meager, and the comparison of Dr. Wolf's relative numbers with the range of the magnetic declination led me to think that his relative numbers were somewhat too large. Dr. Wolf's new discussion of the observations has led him to a slight increase instead of a diminution of his former numbers. The following statement will show how little weight is to be attached to these numbers. The year of supposed maximum in the extent of the solar spots, is 1804. Now for the year 1802, Dr. Wolf has only *eight* observations from which he is able to deduce a value for his relative number; for 1803, he has but *two* observations; for 1804, but *three;* for 1805, but *one;* and for 1806, but *four* observations.

Now for the year 1870, in which he had himself carefully observed the solar spots on 276 days, and had received observations from other astronomers which informed him of the condition of the sun's surface on 352 days of the year, he obtained 173·3 as the correct value of the relative number; or by a dif-

ferent mode of computation he might reduce this number to 169·1, and these are the values which he published in the Vierteljahrsschrift, vol. xvi, pp. 84–85. But it would seem as if he subsequently became alarmed at the discrepancy between these numbers and the range of the magnetic needle as reported from the observatories of Munich and Prague, and in the Vierteljahrsschrift, vol. xvii, pp. 2–6, he undertakes a new discussion of these observations and reduces the relative number for 1870 to 139·6. If, when his materials were so abundant as in 1870, he could, by a change in his mode of reduction, produce a difference of 30 in his relative number for the year, it seems quite allowable to conclude that for the years 1801–1807, during which we have extremely few observations, Dr. Wolf's relative numbers may require a still larger correction.

As, however, the main object of this article is to establish the periodical character of auroral displays, I prefer to take Dr. Wolf's relative numbers precisely as he has furnished them in his latest publications, without insisting upon any further modification, although I still think some modification is called for in a few cases. The following table shows the relative numbers representing the frequency and extent of the solar spots for each year since 1776, according to what I understand to be Dr. Wolf's latest determinations. I begin the comparison with the year 1776, because that is the year on which the observations of the magnetic needle commence. The relative numbers from 1784 to 1811 inclusive, are taken from the Vierteljahrsschrift, vol. xvi, p. 86; the others are taken from the Vierteljahrsschrift, vol. xiii, p. 121, with the exception of the last four years, which are taken from more recent volumes of the Vierteljahrsschrift.

Table of relative extent of solar spots each year.

Year.	Extent of spots.	Year.	Extent of spots.	Year.	Extent of spots.	Year.	Extent of spots.	Year.	Extent of spots.	Year.	Extent of spots.
1776	35·2	1792	47·5	1808	7·2	1824	6·7	1840	51·8	1856	4·2
1777	63·0	1793	40·2	1809	3·4	1825	17·4	1841	29·7	1857	21·6
1778	94·8	1794	34·3	1810	0·0	1826	29·4	1842	19·5	1858	50·9
1779	90·2	1795	22·3	1811	1·2	1827	39·9	1843	8·6	1859	96·4
1780	72·6	1796	15·1	1812	5·4	1828	52·5	1844	13·0	1860	98·6
1781	67·7	1797	7·8	1813	13·7	1829	53·5	1845	33·0	1861	77·4
1782	33·2	1798	4·4	1814	20·0	1830	59·1	1846	47·0	1862	59·4
1783	22·5	1799	10·2	1815	35·0	1831	38·8	1847	79·4	1863	44·4
1784	5·0	1800	18·5	1816	45·5	1832	22·5	1848	100·4	1864	47·1
1785	21·2	1801	38·6	1817	43·5	1833	7·5	1849	95·6	1865	32·5
1786	68·6	1802	57·8	1818	34·1	1834	11·4	1850	64·5	1866	17·5
1787	104·8	1803	65·0	1819	22·5	1835	45·5	1851	61·9	1867	8·0
1788	107·8	1804	75·0	1820	8·9	1836	96·7	1852	52·2	1868	40·2
1789	110·7	1805	50·0	1821	4·3	1837	111·0	1853	37·7	1869	84·1
1790	84·4	1806	25·0	1822	2·9	1838	82·6	1854	19·2	1870	139·6
1791	53·4	1807	15·0	1823	1·3	1839	68·5	1855	6·9	1871	109·6

These numbers have all been projected upon the lower portion of the accompanying chart, Plate II, and the curve line thus obtained is therefore to be regarded as indicating the fluctuations in the sun's spotted surface since 1776, according to the results of Dr. Wolf.

For the daily range of the magnetic declination, I have not been able to obtain any new observations with the exception of the last few years. The following are the values of the mean diurnal inequality of the magnetic declination as observed at Prague, since 1851, derived partly from the Vierteljahrsschrift and partly from the Beobachtungen zu Prag. Some of these numbers differ from those given in my former article (this Jour., vol. 50, p. 161), those values for some of the years being simply the difference between the mean declination for the year at 8 A. M. and 2 P. M.

Diurnal inequality of the magnetic declination at Prague.

Year.	Dec'n.	Authority.	Year.	Dec'n.	Authority.
1851	8′·32	Vierteljahrsschrift, iv, p. 225	1862	8′·59	Vierteljahrsschrift, ix, p. 116
1852	8·09	" "	1863	8·84	" "
1853	7·09	" "	1864	8·02	" x, p. 155
1854	6·81	" "	1865	8·14	Prag Beobach., 1870, p. 16
1855	6·41	" "	1866	7·65	" "
1856	5·98	" "	1867	7·09	" "
1857	6·95	" "	1868	8·15	" "
1858	7·41	" "	1869	9·44	" "
1859	10·37	" vi, p. 418	1870	11·41	" 1871, p. 21
1860	10·05	" "	1871	11·60	" "
1861	9·17	" vii, p. 230			

These numbers, combined with those given in my former article from 1777 to 1850 (this Jour., vol. 50, p. 161), are projected upon the accompanying chart, and the curve thence resulting is regarded as representing the mean daily range of the magnetic declination at Prague, as nearly as can be deduced from all the observations. The irregularity exhibited in my former article for the year 1791 has been corrected, as having no sufficient basis, it having resulted from the fact that, for 1790, the value employed was deduced from combining a large value at London with a small one at Mannheim, while for 1792, the value employed rested solely upon the London observation.

For the number of auroral exhibitions each year, I have depended almost exclusively upon the catalogues of auroras by Prof. Joseph Lovering. These catalogues consist of a general list of auroral displays from 500 B. C. to 1864, embracing about 10,000 cases; also a second list, embracing nearly two thousand additional cases; and a third supplementary list, containing several hundred cases not included in either of the preceding lists. Finally, there are four pages of addenda and

errata, some of them of great importance. All of these materials I have endeavored to combine in a single catalogue.

In attempting to decide whether auroral displays exhibit a true periodicity, it is evident that some discrimination should be used in selecting our data for comparison. If for each year we employ the total number of auroral observations reported from all parts of the world, the numbers thus resulting exhibit a great inequality on those years for which we have reports from high northern latitudes, as happens in the years 1820, 1838, 1850, 1852, etc. Inasmuch as the observations from these high latitudes are not continuous but are confined to single years generally separated by a considerable interval, it seems necessary to exclude them entirely from the present comparison. Moreover in my former article (this Jour., vol. 50, p. 165), I have given reasons for thinking that in the high northern latitudes the inequality of the auroral displays on different years consists more in unequal *brilliancy* than in unequal *frequency* of exhibition; and therefore I have decided to leave out of the account not only those occasional observations from very high latitudes, but observations from certain lower latitudes from which the reports are tolerably complete and continuous. The geographical line of division has not, however, been drawn in an irregular manner for the purpose of including stations from which the observations would favor a pre-conceived theory, and excluding stations from which the observations were unsatisfactory, but it is designed to be a line of *equal auroral frequency*, as determined in an article published in this Journal in July, 1860. I have chosen for my northern boundary the northern line of the State of Massachusetts, and through this boundary have traced a line of equal auroral frequency across the Atlantic ocean and the continent of Europe. (See Plate I).

As the observations from the southern hemisphere do not form a long series, I exclude them entirely from the present comparison; and for the same reason I exclude the continent of Asia, and also all the western portion of the United States. I have selected as the eastern boundary the meridian of 40 degrees of longitude east from Greenwich; and as the western boundary the meridian of 80 degrees of longitude west from Greenwich. The portion of the earth's surface selected for comparison is shown on the accompanying chart, and the northern boundary of this area is shown by the undulating line crossing the chart from east to west. This line passes a little north of St. Petersburg; a little south of Abo, Upsal and Stockholm; north of Copenhagen; follows nearly the boundary between England and Scotland; passes south of Nova Scotia; follows the northern boundary of Massachusetts; and divides the State of New York by the parallel of 42° 45′. It will

readily be seen that the area thus indicated embraces the whole of the earth's surface from which we have any long continued series of auroral observations, with the exception of a few stations on the north. I have endeavored to determine whether within these geographical limits a periodicity can be detected in the frequency of auroral displays, and for this purpose I have employed every known auroral observation within these limits since the year 1776, and I commence the comparison at this point because this is the date of commencement of the magnetic observations, with which the auroral observations are to be compared. The following list is supposed to contain the date of every aurora since 1776, mentioned in either of Prof. Lovering's catalogues, from any station within the geographical limits above stated. Prof. Lovering's catalogue closes with the year 1868, and as a very important maximum has recently occurred, I have endeavored to render the list as complete as possible down to the close of the year 1872. For the American observations during this period I am indebted to the kindness of Prof. Joseph Henry, Secretary of the Smithsonian Institution, who has afforded me the opportunity of examining the manuscript records of that institution. At the time of my examination, the meteorological reports for December, 1872, had not been received at Washington. To supply this omission I addressed letters to a large number of the Smithsonian observers who have been most assiduous in watching for auroras, but they all reported no aurora seen in December, 1872.

To my numerous correspondents who have kindly furnished me materials for this article, I here publicly present my acknowledgements.

For the European observations since 1867, I have depended mainly upon Heis' Wochenschrift, and have aimed to include every aurora reported in that journal from any station within the geographical limits above mentioned. A few additional cases have been derived from other journals.

Although Prof. Lovering's catalogues are very extensive, it is evident that they are not complete. On page 187 there is given a tabular statement of the number of auroras seen at St. Petersburg from 1841 to 1861, and this number is about four times as great as the number of auroras at St. Petersburg, for which the dates are given in either of the catalogues.

I have consulted all the works which were accessible to me, and in which I might expect to find a record of recent auroral observations, and have found the following sixteen cases not named in Prof. Lovering's catalogues:

1859. Feb. 28. Middletown, Conn., Prof. John Johnston.
1859. April 30. " " " " "
1859. Oct. 17. Greenwich Met. Obs., 1859, p. 161; Oxford Met. Obs., p. 30.

1859. Nov. 2. Switzerland, Comptes Rendus, vol. xlix, p. 662.
1860. March 16. Middletown, Conn., Prof. John Johnston.
1860. May 9. Oxford Met. Obs., 1860, p. 76.
1861. Jan. 20. Dorpat. Nederlandsch Met. Jaarboek, 1861, p. 286.
1861. Feb. 28. Middletown, Conn., Prof. John Johnston.
1861. March 1. " " " " " Oxford Met. Obs., p. 27.
1861. March 8. " " " " "
1861. March 10. Paris, Comptes Rendus, vol. lii, p. 465.
1861. Aug. 12. Yverdon, Switzerland, Wolf's Vierteljahrsschrift, vol. xi, p. 467.
1861. Oct. 6. Middletown, Conn., Prof. John Johnston.
1861. Oct. 12. Greenwich Met. Obs., 1861, p. 147.
1861. Oct. 25. Washington Met. Obs., 1861, p. 497.
1861. Nov. 24. Oxford Met. Obs., p. 30.

The following table shows the dates of the entire series of auroras within the geographical limits before indicated:

Catalogue of Auroras from 1776 *to* 1872.

1776. Jan. 18, 20, 21, Feb. 11, March 9, 13, 23, 28, April 8, 10, 18, 19, May 3, 21, 23, 25, June 6, 7, July 7, Aug. 14, Sept. 3, 4, 5, 6, 8, 9, 12, 16, 19, 22, 23, 24, 25, Oct. 3, 6, 7, 27, Nov. 16, Dec. 16; total 39.

1777. Jan. 13, 28, 30, Feb. 5, 6, 7, 10, 17, 26, 27, March 1, 5, 6, 9, 10, 11, 12, 14, 22, 28, 29, 31, April 1, 4, 5, 6, 7, 8, 9, 11, 12, May 4, 5, 13, 21, 30, 31, June 28, July 27, Aug. 6, 17, 24, 26, 27, 30, Sept. 4, 5, 6, 7, 15, 24, 26, 28, 30, Oct. 3, 8, 10, 13, 22, 24, 25, Nov. 3, 6, 7, 9, 21, 23, 27, 28, Dec. 1, 2, 3, 4, 5, 6, 17, 18, 21, 27, 30, 31; total 81.

1778. Jan. 18, 19, 20, 21, 25, 26, 27, Feb. 1, 15, 16, 17, 18, 25, 26, 28, March 10, 15, 16, 17, 18, 19, 22, 24, 25, 26, 27, 31, April 10, 14, 15, 17, 18, 19, 20, 21, 23, 26, May 13, 14, June 10, 11, 14, 26, 28, July 3, 7, 15, 31, Aug. 12, 18, 22, 28, Sept. 1, 3, 11, 12, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 27, 30, Oct. 9, 14, 15, 19, 23, 25, 26, 27, Nov. 20, 24, Dec. 3, 6, 7, 8, 10, 13, 14, 15, 17, 26; total 88.

1779. Jan. 6, 9, 10, 12, 13, 14, 19, Feb. 4, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 25, March 2, 5, 13, 14, 15, 24, 25, 30, 31, April 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 17, 18, 20, 21, 22, 28, May 2, 4, 6, 7, 8, 10, 11, 12, 13, 15, 17, 20, 22, 24, 25, June 3, 5, 14, 15, 20, 24, July 9, 15, 17, 20, Aug. 3, 4, 8, 14, 17, 20, 26, 28, 29, 30, Sept. 2, 4, 8, 10, 11, 14, 15, 17, 18, 19, 22, 24, 28, 29, Oct. 3, 4, 9, 12, 14, 15, 17, 19, 22, 28, Nov. 3, 7, 8, 9, 12, 13, 14, 15, 18, 25, Dec. 3, 5, 6, 8, 9, 10; total 123.

1780. Feb. 5, 11, 15, 22, 29, March 1, 2, 29, 30, 31, April 4, 6, 13, May 8, 17, June 15, 23, 24, July 9, 11, 18, 20, 27, 28, 29, Aug. 2, 15, 27, Sept. 2, 3, 4, 7, 10, 11, 21, 22, 27, Oct. 4, 6, 10, 24, 28, 30, Nov. 4, 14, 19, 20, 21, 22, 23, 25, 26, 27, 28, 29, Dec. 7, 15, 19, 25, 27, 30, 31; total 62.

1781. Jan. 1, 17, 21, 22, 23, 25, 28, 29, 30, 31, Feb. 2, 5, 15, 16, 21, March 14, 16, 19, 20, 22, 23, 27, 28, 29, 31, April 4, 13, 14, 15, 16, 17, 19, 21, 24, 25, 26, 28, May 4, 11, 14, 16, 17, 18, June 6, 7, 8, 9, 19, 20, 28, 29, July 9, 22, Aug. 6, 8, 12, 14, 16, 17, 20, 21, 22, 23, 25, 26, Sept. 3, 7, 8, 9, 18, 19, 22, 23, 24, 25, 26, Oct. 3, 4, 8, 14, 15, 16, 19, 21, Nov. 13, 14, 15, 16, 19, Dec. 9, 10, 11, 12, 16, 19, 22, 30; total 97.

1782. Jan. 2, 4, 5, 8, 9, 10, 12, Feb, 3, 6, 15, 16, 17, 18, 25, March 7, 9, 10, 14, 15, 17, 19, 29, 30, 31, April 1, 2, 4, 6, 7, 13, 14, 27, May 4, 5, 6, 7, 9, 16, 17, 18, 20, 22, 23, 24, June 1, 4, 5, 6, 13, July 9, 10, 20, 31, Aug. 4, 5, 12, 22, 26, 27, 28, 30, Sept. 2, 3, 5, 6, 9, 10, 12, 13, 14, 15, 22, 29, 30, Oct. 1, 2, 3, 5, 8, 9, 10, 11, 14, 17, 26, Nov. 19, 20, 26, Dec. 29, 31; total 90.

1783. Jan. 9, 13, 26, 30, 31, Feb. 1, 2, 12, 21, 27, 28, March 1, 2, 4, 9, 16, 18, 20, 21, 22, 24, 25, 26, 27, 29, 30, 31, April 2, 3, 7, 9, 11, 12, 14, 18, 21, 22, 24, 25, 26, 27, 28, 29, 30, May 1, 2, 3, 4, 5, 12, 13, 16, 17, 21, 22, 29, June 1, 3, 13, 29, July 28, 30, Aug. 1, 2, 8, 9, 16, 19, Sept. 15, 25, 26, Oct. 22, 23, 24, 26, 27, 29, 30, 31, Nov. 3, 11, 13, 14, 15, 26, Dec. 4, 17, 18; total 88.

1784. Jan. 10, 11, 20, 21, Feb. 22, March 5, 12, 13, 14, 15, 18, 29, April 8, 9, 15, 16, 18. 21. May 6, 9, 12, 17, 22, June 11, 16, 17, 21, 30, July 1, 3, 24, 25, 26, Aug. 4, 5, 12, 15. 21, 30, Sept. 6, 8, 11, 12, 15, Oct. 4, Nov. 13, 15, Dec. 6, 11, 29, 31: total 51.

1785. Jan. 17, 26, 28, 29, Feb. 3, 7, 16, 17, 22, 23, March 3, 6, 19, 22, April 3, 7, 12, 26. 27, 29, May 1. 9, 15, June 5, 14. 28, July 3, 4, 17, 24, Aug. 3, 9, 11, 30, 31, Sept. 8, 11. 12, 13, 14, 23, Oct. 4, 5, 6, 8, 9, 22, Nov. 2, 5, 6, 29, 30, Dec. 13, 19, 30; total 55.

1786. Jan. 4, 14, 18, 29, 30. Feb. 3. 16, 17, 20, 27, 28, March 1, 2, 3, 4, 11, 13, 16, 18, 19, 20, 21, 22. 23, 25, 27, 28, 29, 30, 31, April 1, 2, 3, 6, 11, 12, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, May 1, 2, 3. 4, 5, 8, 11, 12, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 30, 31, June 1, 4, 5, 19, 28, 30, July 1, 2, 5, 13, 15, 16, 17, 18, 19, 20, 22, 24, 25, 27, 29, Aug. 2, 3, 11, 16, 17, 18, 19, 21, 22, 24, 25, 31, Sept. 2, 3, 5, 8, 14, 17, 19, 20, 21, 26, 28. 29, Oct. 1, 2, 10, 12, 13, 14, 16, 17, 18, 19, 20, 22, 23, 25, 27, 28, Nov. 8, 12, 13, 14, 15, 16, 18, 20, 21, Dec. 3, 5, 15, 18, 20; total 143.

1787. Jan. 9, 12, 16, 17, 21, 22, 24, 25, 29, Feb. 3, 4, 6, 9, 12, 15, 17, 20, 22, 25, 27, March 6, 7, 10, 13, 16, 17, 18, 20, 21, 23, 24, 26, 31, April 2, 6, 12, 14, 16, 17, 18, 19, 20, 21, 22, 23, 26, May 4, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 25, 29, June 2, 5, 6, 7, 8, 9, 10, 14, 15, 16, 18. 19, 24, July 1, 4, 11, 13, 14, 16, 18, 20, 22, 23, 30, Aug. 1, 7, 10, 13, 19, 21, 25, 30, Sept. 6, 7, 8, 10, 18, 19, 23, 26, 28, Oct. 3, 4, 5, 6, 7, 10, 12, 13. 14. 16, 17, 19, 20, 21, 24, 31, Nov. 2, 3, 4, 7, 8, 9, 10, 12, 13, 20, 21, 24, 26. 29, 30, Dec. 1, 6, 8, 9, 10, 15, 16; total 139.

1788. Jan. 3, 4, 5, 8, 9, 10, 13, 14, 15, Feb. 2, 4, 5, 6, 7, 9, 11, 12, 15, 22, March 3, 7, 8, 14, 22, 27, 28, April 1, 2, 3, 4, 6, 7, 10, 14, 21, 24, 26, 27, 28, 29, 30, May 1. 2, 3, 4, 5, 6, 7, 10, 11, 24, 25, 26. 27, 28, 29, 30, 31, June 3. 4, 5, 9, 25, 27, 28, July 1, 2, 3, 5, 14, 15, 25, 30. 31, Aug. 1, 2, 3, 11, 19, 20, 22, 23, 24, 26, 27, 28. 29, 31, Sept. 1, 2, 3, 4, 5, 6. 7. 10, 12, 20, 24, 25, 26, 27, 28, 29, Oct. 4, 5, 6, 12, 13. 18, 21. 22, 25, 26, 27, 28, 29, 30. 31, Nov. 1, 2, 3, 18, 19, 23, 26, 27, 28, Dec. 8, 15, 16, 20, 21, 23, 30; total 135.

1789. Jan. 19, 21, 24, 29, 30, Feb. 2, 6, 15, 16, 23, 26, March 14, 20, 22, 26, 27, 28, 29. 30, 31, April 2, 9, 17, 20, 26, 27, 29, 30, May 15, 16. 17, 20, 21, 22, 23, 24, 28. 29, 31. June 2, 12, 13, 15. 16. 17, 18, 19, 20, 23, 29, 30, July 10, 11, 14, 15, 17, 18, 19, 20, 23, 24, 25, 26. 27, 28, 29, Aug. 13, 14, 15, 16, 17, 18, 19, 20, 24, 25, Sept. 9, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26. Oct. 11, 16, 18, 19, 20. 21. 23, 24, 27, Nov. 4. 6, 10, 14, 15, 18, 19, 20, 21, 22, 24, 30, Dec. 10, 13, 14, 15, 16, 18, 19, 20, 22, 24; total 118.

1790. Jan. 9, 10, 18, 28, 29, Feb. 1, 3, 4, 11, 12, 13, 14, 15, 24, March 3, 8, 16, 17, 18, April 2, 3, 4, 5, 6, 7, 8, 9. 11, 16, 17, 30, May 1, 12, 14, 16, 17, 18 24, 30. June 3, 4, 5, 8, 22, 25, 30, July 1, 3, 13, 16, Aug. 3, 16, 19. Sept. 6, 7, 9, 16, 19, 24. 30, Oct. 1, 4, 9, 14, 18, 31, Nov. 4, 5, 6, 7, 8, 9, 10, 12, 16, 26. 27, 28, 30. Dec. 25. 28, 30; total 82.

1791. Jan. 6, 7, 9, 12. 20, 25, 28, 29, Feb. 21, 24, 25, 27, March 2, 3, 5, 7, 20. 22, 26, 29, April 1, 3, 5, 13, 18, 20, 23, 25, May 5, 12, 20, 23, 26, June 10, 19. 26, July 7, 20, 22, 23, 24, 28. Aug. 8, 18, 20, Sept. 8, 11, 13, 15, 27, 28, Oct. 2, 6, 15, 19, 20, 21, 22, 23, 28, 29, 31, Nov. 3, 4. 5, 8, 11, 14, 16, 17, 18, 19, Dec. 13, 19, 23, 26, 27, 28, 29; total 79.

1792. Jan. 9, 16, 17, 18, 24, 25, 30, Feb. 9, 17, March 2, 5, 15, 16, 19, 25, 27, 31, April 10, 11, 12, 13, 14. 16, May 6, 8, 9, 14, 15, 20, 22, 27, June 2, 30, July 7. 11, 18, 19, Aug. 2, 4, 17, 23. 27, Sept. 1, 6, 14, 22, 28, Oct. 12, 13, 14, 15. 16, 17, 18, 23, 31, Nov. 13, 14, 19. 29, Dec. 2, 7, 12, 13, 15, 30; total 66.

1793. Jan. 11, 12, 13, 14, Feb. 8, 12, 15, March 4, 5, 6, 13, 30, April 5, 9, 14, June 9, Aug. 6, 26, 28, Sept. 2, 4, Oct. 20, Nov. 8; total 23.

1794. Jan. 7, 22, March 8, 29, April 2, 3, 30, Nov. 11, Dec. 7, 8, 19; total 11.

1795. March 11, May 24, Sept. 8, 14, Oct. 3, 14, 16, 17, 18; total 9.

1796. Feb. 6, April 6, May 22: total 3.

1797. Jan. 22. Feb. 1, 10, 18, 27, 28, March 1, 2, 10, April 24, Nov. 18, 21, 22, 23, Dec. 20; total 15.

1798. Jan. 15; total 1.

1799. Jan. 22, Feb. 25, July 23, 24, Sept. 3, 4, Oct. 25; total 7.

1800. March 18. Aug. 15, 18, Nov. 2, 7, Dec. 10; total 6.
1801. Jan. 4, 25, Feb. 22, Aug. 18, Oct. 6; total 5.
1802. Feb. 3, March 29, June 3, 16, July 1, Sept. 19, 27, Dec. 13; total 8.
1803. Jan. 13, March 19, April 12, 13, Aug. 23, Sept. 11, 17, 19, Oct. 12, Dec. 3; total 10.
1804. Feb. 2, March 29, April 1, 4, May 2, 12, Sept. 7, Oct. 12, 22, Nov. 5, 22, 25; total 12.
1805. Jan. 1, 4, Feb. 23, March 26, April 30, May 27, 28, Aug. 29, Sept. 15, 21, 22, 24, Oct. 13, 20, 22, Nov. 16, 18, 19, 20, 25, 26, Dec. 26; total 22.
1806. Jan. 11, Feb. 7, March 16, April 13, Aug. 9, Sept. 10, Oct. 2, 5, Nov. 2, 30, Dec. 22; total 11.
1807. Jan. 13, 26, March 26, April 11, May 8; total 5.
1808. March 8, July 23, 31; total 3.
1809. Jan. 31, June 13; total 2.
1810. Oct. 5; total 1.
1811. None.
1812. None.
1813. June 24, Sept. 24; total 2.
1814. Feb. 28, April 7, 14, 15, 17, May 22, Sept. 10, 11, Oct. 22; total 9.
1815. March 2, May 29, Sept. 26; total 3.
1816. May 17, Sept. 15, Oct. 7; total 3.
1817. Feb. 6, 8, 9, 10, 18, 20, March 4, June 12, Aug. 16, Sept. 19, Oct. 17; total 11.
1818. Jan. 11, April 4, May 23, 28, June 6, 7, 8, 9, 10, Sept. 20, 24, 25, 26, 27, Oct. 6, 7, 26, 31; total 18.
1819. Feb. 1, 19, March 25, 26, April 26, Oct. 3, 12, 15, 17, 31, Nov. 13, 14, Dec. 14; total 13.
1820. Jan. 14, Feb. 11, April 3, May 1, Dec. 4; total 5.
1821. March 25, Nov. 26, Dec. 12; total 3.
1822. Feb. 13, Oct. 22; total 2.
1823. None.
1824. Aug. 10, Sept. 29; total 2.
1825. March 19, April 14, Aug. 17, Sept. 11, Oct. 7, Nov. 3, 22, Dec. 7; total 8.
1826. Jan. 16, 21, March 29, April 29, Sept. 9, Oct. 2; total 6.
1827. Jan. 9, 16, 18, Feb. 13, 17, April 6, 16, Aug. 25, 26, 27, 28, 29, 31, Sept. 8, 9, 25, 26, 27, 28, Oct. 6, 17, 19, Nov. 9, 18, 19, Dec. 8, 27; total 27.
1828. Jan. 16, 18, 19, Feb. 12, April 11, 12, June 2, July 5, Aug. 14, Sept. 8, 15, 25, 26, 27, 29, 30, Oct. 3. 8, 9, 11, 15, 29. Dec. 1, 22, 26, 28; total 26.
1829. Jan. 2, 28, Feb. 11, March 4, 6. 18, 22, 23, April 4, May 2, 4, June 17, 21, 25. July 25, Aug. 25, 29, Sept. 18, 19, 21, 26. Oct. 3, 6, 11, 17, 25, 27, Nov. 17, 18. 19, Dec. 14, 19, 20, 28; total 34.
1830. Jan. 25, 28, Feb. 19, 23, 24, March 15. 18, 24, 28. April 15, 19, 20, 24, May 4, 5, 6, 9, 10, 13, 14, 15, 19, June 10, 11, 17, 29, July 14, 15, 28, Aug. 15, 20, 28, Sept. 7, 8, 9, 10, 12, 13, 15, 16, 17, 18, 19, 20, 21, 23, 25, Oct. 5, 6, 7, 8, 9, 10, 13, 16, 17, 18, 22, 28, Nov. 1, 3, 4, 7, 10, 19, 20, Dec. 7, 8, 10, 11, 12, 13, 14, 15, 22, 25, 30; total 77.
1831. Jan. 5, 6, 7, 8, 10, 11, 21, Feb. 6, 7, 11, 14, 17, March 1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 13, 15, 24, April 1, 3, 18, 19, 20, 23, May 8, 30, June 10, 11, 16, 17, 21, July 3, 4, 5, 10, 30, 31, Aug. 3, 4, 5, 19, Sept. 12, 13, Oct. 29, Nov. 29; total 52.
1832. Jan. 22, 27, Feb. 2, March 27. April 10, May 12. June 27, Aug. 22, 23, 24, Sept. 17, 23, 30, Oct. 7, 12, Nov. 1, 4, 12, 13, 14, 27, Dec. 21; total 22.
1833. Jan. 2, Feb. 11, 18, 19, March 13, 21, April 24, May 16. 17, 18, June 14, 17, July 10, 13. Aug. 1, 6, 21, Sept. 1, 2. 5, 10, 12, 17, 18, Oct. 4, 12, 13, 14, Nov. 3, 12, 13, Dec. 15, 29, 30; total 34.
1834. Jan. 5, 7, 15. Feb. 7, 8, 10, 20, March 3. 4. May 3, June 28, July 28, Sept. 30, Oct. 1, 8, 23, Nov. 2. 3, 5, 6, 28, Dec. 3 4, 6, 21, 22, 23; total 27.
1835. Jan. 4, 29. Feb. 7. March 1, June 21, July 29, Aug. 19, Sept. 4, 7, 9, 22, 24, Oct. 18, Nov. 17, 18, Dec. 10, 21; total 17.
1836. Feb. 11, March 17, April 20, 21, 22. 23, May 8, 19, 20, June 5. 8, 9, 10, July 3, 30, 31, Aug 1, 2, 10, 11, 12, 13, 14, 21, Sept. 13, 15, 29, Oct. 10, 11, 12, 15, 18, 19, Nov. 1, 15, 27; total 36.

1837. Jan. 2, 24, 25, 26, Feb. 13, 14, 18, March 1, 10, 29, April 6, 21, May 2, 6, 19, June 1, 2, 3, 24, July 1, 2, 3, 7, 25, 28, 29, Aug. 3, 25, 27, 28, 29, Sept. 18, 20, 21, 22, 23, 24, 29, Oct. 6, 18, 21, 22, Nov. 1, 5, 6, 12, 14, 15, 17, 18, 30, Dec. 1, 4, 5, 28, 30; total 56.

1838. Jan. 5, 15, 16, 24, 25, 28, Feb. 3, 4, 18, 20, 21, 22, 23, 26, March 15, 19, April 12, 29, 30, May 13, 14, June 25, 26, July 13, 14, 15, 27, 29, Aug. 22, 23, 28, Sept. 5, 7, 10, 13, 14, 15, 16, 17, 20, Oct. 16, Nov. 12, 13, 14, 25, 26, Dec. 13; total 47.

1839. Jan. 10, 11, 14, 16, 19, 21, Feb. 4, 18, March 5, 10, 15, 19, 22, 24, April 7, 8, 20, 21, May 5, 7, 9, 10, 11, 14, 15, 17, 31, June 6, 7, 12, July 3, 4, 30, Aug. 10, 20, 28, 31, Sept. 1, 2, 3, 4, 14, 15, 19, 21, 28, Oct. 8, 10, 11, 22, 31, Nov. 4, 6, 8, 11, 13, 17, 23, 30, Dec. 4, 14, 21, 31; total 63.

1840. Jan. 3, 4, 5, 8, 30, 31, Feb 6, 7, 21, March 5, 6, 22, 29, 31, April 1, 4, 5, 15, 19, 20, 23, 24, May 1, 6, 20, 28, 29, 30, June 1, 10, 14, 21, 22, 26, July 4, 16, 25, 29, Aug. 19, 24, 25, 26, 28, 29, 31, Sept. 1, 19, 21, 22, 23, Oct. 21, 22, 23, 27, 29, 31, Nov. 12, 13, 15, 19, 20, 23, 29, 30, Dec. 11, 13, 14, 17, 19, 21, 22, 24, 28, 29; total 74.

1841. Jan. 14, 22, 25, 27, 28, Feb. 7, 8, 11, 12, 15, 18, 19, 22, 23, 24, March 11, 12, 14, 15, 16, 17, 19, 20, 21, 22, 23, 24, 25, April 11, 14, 16, 18, 19, May 3, 8, June 11, 15, 16, 17, 21, July 11, 19, 21, 24, 29, Aug. 2, 5, 6, 14, 23, Sept. 10, 12, 13, 14, 18, 25, 26, Oct. 6, 9, 13, 14, 15, 18, 19, 20, 21, 25, Nov. 5, 8, 15, 17, 18, Dec. 1, 12, 13, 14, 15, 19, 20, 21, 24; total 81.

1842. Jan. 2, 4, 5, 7, 9, 11, 12, 15, 20, 24, Feb. 1, 2, 6, 11, 12, 13, 24, March 3, 7, 15, 23, April 3, 10, 11, 12, 13, 14, 15, 16, 20, June 7, 9, 30, July 3, 11, 31, Aug. 5, 8, 9, 23, Sept. 2, 28, Oct. 7, 16, 17, 18, Nov. 3, 6, 21, 24, 28, Dec. 17, 27; total 53.

1843. Jan. 2, Feb. 24, March 2, 4, 6, 12, 13, 17, April 2, 5, 6, 22, May 6, 7, 9, 13, 17, 23, June 15, 27, 30, July 7, 19, 25, Aug. 3, Sept. 13, 18, 27, 28, Oct. 14, 19, Nov. 15, 27, Dec. 8, 12, 29; total 36.

1844. Jan. 8, 12, 13, 19, 24, 27, Feb. 11, 20, March 4, 7, 25, April 5, 17, May 7, 8, 14, 22, June 12, 16, 22, Aug. 1, 9, 11, 29, Sept. 30, Oct. 20, Nov. 5, 6, 13, 14, 16, Dec. 8, 14, 29; total 34.

1845. Jan. 6, 9, 10, 12, 29, Feb. 13, 25, March 9, 16, 18, April 13, 27, 30, May 1, 5, 29, June 5, 17, 24, 25, July 4, 8, 24, 25, 28, 31, Aug. 1, 4, 29, 30, Sept. 1, 7, 24, 25, 26, 27, Oct. 9, 21, Nov. 27, Dec. 2, 3, 4, 5, 14, 16, 29, 30, 31; total 48.

1846. Jan. 3, 4, 19, 20, 23, 28, 31, Feb. 18, 19, 25, 26, March 14, 17, 25, 28, April 6, 12, 15, 16, May 3, 4, 10, 12, 13, 14, 18, 19, June 14, July 12, 14, 15, 25, Aug. 6, 11, 12, 18, 24, 28, 29, 30, Sept. 1, 9, 10, 11, 21, 22, 23, Oct. 7, 8, 10, 11, 15, 19, 21, 22, 24, Nov. 11, 13, 17, 18, 21, Dec. 4, 9, 11, 13, 14, 16, 22, 23; total 69.

1847. Jan. 13, 14, 17, 21, 25, Feb. 6, 7, March 5, 8, 11, 17, 19, 26, 28, April 4, 6, 7, 16, May 7, 15, June 6, 12, July 9, 11, Aug. 3, 4, 21, 25, Sept. 13, 15, 16, 24, 26, 28, 29, 30, Oct. 3, 13, 14, 24, 25, 27, Nov. 1, 2, 10, 11, 12, 14, 18, 25, 26, Dec. 4, 15, 16, 17, 19, 20, 31; total 58.

1848. Jan. 3, 6, 16, 23, 28, Feb. 4, 6, 7, 8, 15, 18, 20, 21, 22, 23, 24, 25, 26, March 7, 8, 15, 17, 19, 20, 22, 24, 25, 28, 29, 30, 31, April 1, 2, 3, 5, 6, 7, 15, 17, 29, May 13, 18, 24, 25, 27, 31, June 1, 22, July 3, 4, 7, 8, 11, 23, 24, Aug. 8, 14, 19, 21, 22, Sept. 3, 4, 5, 9, 23, 30, Oct. 5, 6, 8, 10, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 30, Nov. 13, 14, 15, 17, 18, 19, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, Dec. 1, 13, 16, 17, 18, 22, 23, 26, 27, 29; total 108.

1849. Jan. 4, 14, 15, 22, 25, 30, Feb. 13, 16, 18, 19, 20, 21, 22, 23, 24, 26, 27, March 16, 17, 18, 19, 25, April 1, 2, 13, 14, 17, 20, 22, 24, 25, 30, May 12 13, 30, 31, June 10, 12, 15, 17, 19, 22, 24, 26, 30, July 1, 10, 11, 12, 13, 22, 23, 24, Aug. 10, 13, 16, 18, Sept. 3, 7, 9, 11, 13, 16, 18, 19, 20, 23, Oct. 1, 4, 13, 14, 15, 18, 20, 22, Nov. 9, 12, 27, 30, Dec. 7, 8, 17; total 82.

1850. Jan. 1, 5, 12, 18, 19, 27, 30, Feb. 1, 3, 4, 6, 9, 10, 12, 13, 14, 15, 21, 22, 26, March 1, 2, 3, 4, 9, 10, 11, 12, 15, 22, 25, 26, 27, 28, 29, 31, April 1, 2, 5, 6, 7, 8, 9, 16, 17, 18, 27, 29, May 3, 7, 8, 12, June 4, 5, 8, 11, 12, 13, 24, 26, 27, 29, July 3, 5, 6, 9, 10, 11, 12, 21, 22, 27, 28, Aug. 6, 9, 10, 11, 12, 13, 16, 17, 18, 21, 26, 28, 29, 30, Sept. 3, 4, 6, 8, 10, 11, 12, 13, 14, 15, 28, 29, 30, Oct. 1, 2, 3, 6, 7, 11, 14, 27, 28, 29, 30, Nov. 4, 9, 10, 12, 21, 28, Dec. 1, 3, 20, 26, 27; total 122.

1851. Jan. 1, 5, 9, 12, 19, 21, 23, 24, Feb. 1, 5, 6, 7, 11, 12, 17, 18, 19, 20, 23, 24, 26, 28, March 3, 6, 7, 8, 10, 14, 18, 20, 21, 22, 23, 24, 25, 28, 29, 30, April 3, 7, 8, 10, 18, 21, 24, May 1, 4, 5, 15, 16, 17, 24, 26, June 5, 6, 11, 19, 20, 23, 24, 27, July 7, 17, 26, Aug. 13, 14, 21, 24, 29, 30, Sept. 3, 4, 6, 7, 10, 15, 16, 26, 27, 28, 29, 30, Oct. 1, 2, 3, 14, 15, 18, 20, 21, 23, 28, 29, Nov. 4, 5, 13, 15, 20, 21, 24, 26, Dec. 6, 8, 22, 23, 26, 28, 29, 30; total 109.

1852. Jan. 4, 17, 19, 20, 21, 23, 25, 30, 31, Feb. 4, 15, 16, 17, 18, 19, 20, 21, 23, 25, 26, 27, 28, March 2, 4, 5, 7, 9, 17, 21, 25, 26, 31, April 1, 9, 10, 11, 12, 15, 16, 20, 21, 22, 23, 26, May 1, 2, 3, 10, 17, 18, 19, 20, 21, 25, June 5, 10, 11, 12, 15, 16, 19, 24, July 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, Aug. 8, 11, 14, 15, 24, Sept. 2, 4, 5, 6, 12, 16, 17, 18, 21, 29, Oct. 5, 9, 10, 13, 18, 19, 20, 25, Nov. 3, 7, 10, 11, 12, 14, 15, 16, 30, Dec. 2, 5, 6, 8, 13, 14, 15, 17, 29; total 114.

1853. Jan. 4, 5, 6, 7, 8, 9, 30, 31, Feb. 1, 14, 15, 16, 17, 27, 28, March 7, 8, 9, 10, 13, 14, 17, 18, 27, 29, April 5, 6, 7, 8, 9, 10, 11, May 2, 4, 5, 7, 13, 14, 24, 31, June 1, 6, 9, 14, 22, July 12, 16, Aug. 11, 20, 30, Sept. 1, 2, 3, 4, 28, Oct. 6, 23, 25, 29, 30, 31, Nov. 1, 2, 8, 22, Dec. 5, 6, 23, 24, 26, 27, 28, 29, 30; total 74.

1854. Jan. 2, 23, 28, Feb. 2, 4, 16, 17, 27, March 15, 16, 21, 27, 28, 29, 30, April 20, 21, 23, May 1, 15, 16, 19, 21, June 12, 13, July 10, 27, Sept. 13, 14, 21, 22, 23, 26, 27, Oct. 18, Nov. 20; total 36.

1855. Jan. 10, Feb. 5, 6, 12, March 12, 18, April 7, 9, 12, 14, May 10, Sept. 10, 17, Oct. 4, 8, 9, Nov. 29; total 17.

1856. March 12, 30, April 22, June 2, 4, 6, Aug. 22, 24, 31, Oct. 4, 19, 23, Nov. 20; total 13.

1857. Feb. 26, Sept. 1, 3, 7, 8, 10, Nov. 9, 17, Dec. 16, 17, 18, 20; total 12.

1858. Jan. 8, 12, Feb. 16, March 1, 12, 13, 14, April 1, 9, 10, 11, 12, 14, 15, 21, 24, 29, May 1, 2, 6, 7, 10, June 6, July 1, 5, Aug. 30, 31, Sept. 1, 7, 8, 9, 12, 14, Oct. 2, 4, 6, 7, 8, 9, 10, 27, 31, Nov. 1, 10, Dec. 1, 4, 24; total 47.

1859. Jan. 1, 22, 23, Feb. 9, 22, 23, 24, 25, 26, 28, March 2, 25, 26, 27, 29, 30, 31, April 1, 12, 21, 22, 23, 24, 28, 29, 30, May 1, 5, July 15, 28, Aug. 21, 28, 29, 30, 31, Sept. 1, 2, 3, 4, 5, 6, 24, 25, 27, 28, Oct. 1, 2, 12, 17, 18, 19, 20, 21, 24, Nov. 2, 12, Dec. 1, 6, 13, 14, 22, 24; total 62.

1860. Jan. 15, Feb. 12, 21, 22, March 12, 16, 17, 18, 19, 22, 24, 25, 26, 27, 28, April 9, 12, 13, 14, 15, 16, 18, May 6, 9, 10, 23, June 30, July 19, Aug. 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 18, 25, 27, 30, Sept. 6, 7, 8, 15, 16, 25, Oct. 1, 8, 11, 19, Nov. 2, 4, Dec. 8, 10, 15; total 57.

1861. Jan. 12, 13, 20, 22, 23, 24, 31, Feb. 2, 12, 27, 28, March 1, 2, 4, 8, 9, 10, 25, April 7, 8, 15, 25, 26, 28, 29, June 12, Aug. 4, 5, 12, Sept. 8, 10, 11, 15, 25, Oct. 2, 6, 10, 12, 24, 25, Nov. 5, 7, 24, Dec. 2, 3, 4, 19, 20, 23, 24, 26; total 51.

1862. Feb. 21, 22, March 4, 5, 14, April 2, 13, May 2,19, 20, June 4, July 5, 19, 27, Aug. 2, 4, 14, 18, 21, 28, 29, 30, Sept, 11, 24, 25, 27, 28, 30, Oct. 4, 9, 10, 11, 15, 17, 26, Nov. 29, Dec. 14, 15, 24; total 39.

1863. Jan. 25, Feb. 8, 9, 22, 23, March 18, 21, 22, April 6, 9, 19, 21, May 6, 8, 9, June 23, Sept. 7, 8, 9, 23, Oct. 7, 8, 11, Nov. 9, 10, 13, 14, 29, Dec. 10, 11; total 30.

1864. Jan. 5, 6, 14, 17, March 6, 9, 10, 14, April 5, 27, June 7, 18, Aug. 1, 2, 6, 9, 31, Sept. 13, 20, 25, 27, Oct. 8, 15, 19, 21, 29, Nov. 19, 23, 30, Dec. 11, 18, 22, 23, 24, 29, 30, 31; total 37.

1865. Jan. 9, 13, 17, 24, 25, 27, 29, 30, Feb. 7, 17, 18, 20, 21, 22, 23, 27, March 7, 17, 18, 19, 20, 21, 22, 23, 28, 29, April 16, June 17, July 12, 19, Aug. 2, 14, 18, 19, 25, 26, Sept. 12, 15, 16, 17, 21, 26, 28, Oct. 12, 13, 14, 28, 31, Nov. 9, 14, Dec. 15; total 51.

1866. Jan. 8, 16, 27, Feb. 7, 12, 13, 14, 16, March 5, 6, 7, 17, 18, 22, 29, April 16, 17, May 3, 14, June 15, July 12, Sept. 6, 12, Oct. 3, 4, Nov. 9, 11, 19, 29, Dec. 25; total 30.

1867. May 2, 4, 27, July 28, Sept. 21, 23, 25, 26, 29; total 9.

1868. March 19, 24, April 13, 17, 18, 28, May 12, July 10, Sept. 19, 21, 22, Oct. 14, 22, Nov. 14, 16, 19, Dec. 4, 12, 13, 14; total 20.

1869. Jan. 5, 6, 11, 12, 13, 17, 20, 21, Feb. 3, 4, 5, 11, 15, 19, March 1, 5, 7, 9, 10, 14, 18, 31, April 1, 2, 5, 6, 7, 8, 9, 10, 11, 15, 16, 17, May 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 24, 28, 29, June 5, 6, 7, 8, 29, 30, July 15, 16, Aug. 2, 5, 6, 10, 24, 27, Sept. 2, 3, 4, 5, 9, 10, 11, 12, 13, 14, 15, 22, 24, 25, 26, 27, 28, 29, Oct. 3, 5, 6, 17, 18, 21, 25, 31, Nov. 3, 10, 12, 25, Dec. 7, 13, 15, 25; total 95.

1870. Jan. 1, 2, 3, 4, 5, 6, 8, 9, 16, 18, 20, 25, 26, 28, 29, 30, 31, Feb. 1, 2, 3, 4, 5, 11, 12, 13, 17, 19, 22, 23, 24, 28, March 1, 3, 4, 5, 6, 8, 9, 13, 14, 19, 21, 22, 24, 25, 28, 30, 31, April 1, 5, 15, 18, 21, 23, 24, 25, 29, May 1, 19, 20, 22, 27, 31, June 18, July 18, 19, 27, 30, Aug. 7, 12, 19, 20, 21, 28, 29, 31, Sept. 2, 3, 4, 15, 17, 18, 20, 21, 23, 24, 25, 26, 27, 28, Oct. 1, 2, 3, 12, 13, 14, 15, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, Nov. 1, 8, 14, 16, 17, 18, 19, 21, 22, 23, 24, 25, 27, Dec. 10, 15, 16, 17, 21, 22, 23; total 130.

1871. Jan. 12, 13, 15, 16, Feb. 5, 9, 10, 11, 12, 13, 15, 18, 21, 22, 26, March 1, 2, 10, 12, 13, 14, 16, 17, 18, 19, 21, 22, 23, 24, April 1, 5, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 21, 22, 23, 24, 28, 29, May 1, 6, 7, 8, 9, 10, 16, 17, 19, 20, 22, 25, 26, June 7, 10, 11, 12, 14, 16, 17, 18, 21, 26, 27, July 14, 15, 22, Aug. 8, 10, 11, 12, 14, 16, 17, 21, 22, 26, Sept. 4, 6, 7, 8, 9, 10, 11, 13, 15, 20, Oct. 4, 9, 12, 13, 15, 16, 17, 18, 19, Nov. 1, 2, 3, 5, 6, 9, 10, 11, 14, 15, 19, 20, 21, 22, 30, Dec. 7, 8, 9, 10, 14, 28; total 125.

1872. Jan. 5, 6, 7, 10, 15, 30, 31, Feb. 2, 4, 5, 6, 8, 9, 10, 15, 17, 19, 24, 25, 26, 27, 29, March 1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 15, 16, 20, 26, 27, 28, 29, 30, 31, April 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 22, 24, 26, 27, 28, 29, 30, May 3, 6, 7, 25, 26, 27, 28, June 3, 9, 22, 30, July 1, 7, 8, 20, 26, 27, 28, Aug. 1, 3, 4, 5, 8, 9, 10, 14, 24, 25, 27, Sept. 2, 3, 4, 16, 17, 28, Oct. 2, 5, 14, 23, 24, 25, 26, 28, 29, Nov. 1, 2, 4, 8, 9, 10, 13, 19, 23, 24, 25, Dec. 3, 6; total 122.

The total number of auroras for each year as shown in the preceding list is given in column second of the following table. In order to eliminate the effects of irregular and non-periodic causes, I have taken the average of the numbers in column second for each successive period of three years, and the numbers thus resulting are given in column third.

Number of Auroras from 1776 *to* 1872.

Year	Auroras	Mean	Year	Auroras	Mean	Year	Auroras	Mean	Year	Auroras	Mean	Year	Auroras	Mean
1776	39	--	1796	3	9	1816	3	6	1836	36	36	1856	13	14
1777	81	69	1797	15	6	1817	11	11	1837	56	46	1857	12	24
1778	88	97	1798	1	8	1818	18	14	1838	47	55	1858	47	40
1779	123	91	1799	7	5	1819	13	12	1839	63	61	1859	62	55
1780	62	94	1800	6	6	1820	5	7	1840	74	73	1860	57	57
1781	97	83	1801	5	6	1821	3	3	1841	81	69	1861	51	49
1782	90	92	1802	8	8	1822	2	2	1842	53	57	1862	39	40
1783	88	76	1803	10	10	1823	0	1	1843	36	41	1863	30	35
1784	51	65	1804	12	15	1824	2	3	1844	34	39	1864	37	39
1785	55	83	1805	22	15	1825	8	5	1845	48	50	1865	51	39
1786	143	112	1806	11	13	1826	6	14	1846	69	58	1866	30	30
1787	139	139	1807	5	6	1827	27	20	1847	58	78	1867	9	20
1788	135	131	1808	3	3	1828	26	29	1848	108	83	1868	20	41
1789	118	112	1809	2	2	1829	34	46	1849	82	104	1869	95	82
1790	82	93	1810	1	1	1830	77	54	1850	122	104	1870	130	117
1791	79	76	1811	0	0	1831	52	50	1851	109	115	1871	125	126
1792	66	56	1812	0	1	1832	22	36	1852	114	99	1872	122	....
1793	23	33	1813	2	4	1833	34	28	1853	74	75	....	....	....
1794	11	14	1814	9	5	1834	27	26	1854	36	42	....	....	....
1795	9	8	1815	3	5	1835	17	27	1855	17	22	....	....	....

The average number of auroras for each period of three years has been projected upon the accompanying chart, Plate II, which accordingly shows the fluctuations in the frequency of auroras for a period of 96 years. This auroral curve shows great irregularities in the number of auroral exhibitions, but affords unmistakable evidence of a periodic alternation of seasons of abundance with seasons of scarcity.

If we compare the curve showing the mean daily range of the magnetic declination with the curve showing the relative extent of the solar spots, we find a very close correspondence of the curves, and the coincidence in the times of maximum and minimum is quite surprising. The following table shows the dates of maximum and minimum of these two classes of phenomena estimated to the nearest half year. Column third shows the difference between the dates in the first two columns.

Date of Maximum.			Date of Minimum.		
Solar Spots.	Magnetic Declination.	S— M.	Solar Spots.	Magnetic Declination.	S— M.
1778	1777	+1·0	1784	1784	·0
1788.5	1787	+1·5	1798	1799·5	—1·5
1804	1803	+1·0	1810	wanting.	unknown.
1816.5	1817.5	—1·0	1823	1823·5	—0·5
1829.5	1829	+0·5	1833·5	wanting.	unknown.
1837	1838	—1·0	1843·5	1844	—0·5
1848.5	1848.5	·0	1856	1856	·0
1860	1859.5	+0·5	1867	1867	·0
1870	1870.5	—0·5	----	----	----

In only two instances does the difference between the dates of the critical periods of the two phenomena exceed one year. In 1787 the magnetic curve attained its maximum and the sun-spot curve also reached nearly its maximum on the same year, but this unusual solar disturbance was prolonged for a period of three years. In 1798 the sun-spot curve reached its minimum, but the magnetic curve oscillated near its minimum for a period of five years. It is noticeable that the correspondence between the dates of the critical periods for the two phenomena is closest for the more recent period, in which the observations are most numerous and most reliable, and we may therefore presume that a portion of the discrepancy in the undulations of the two curves is due to the imperfection of the earlier observations. A comparison of these observations seems to justify the following conclusions contained in my former article (this Journal, vol. 50, p. 160).

1. A diurnal inequality of the magnetic declination, amounting at Prague to about six minutes, is independent of the changes in the sun's surface from year to year.

2. The excess of the diurnal inequality above six minutes as observed at Prague is nearly proportional to the amount of spotted surface upon the sun, and may therefore be inferred to be produced by this disturbance of the sun's surface, or both disturbances may be ascribed to a common cause.

The correspondence between the auroral curve and the sun-spot curve, though not as close as between the magnetic curve and the sun-spot curve, is certainly quite remarkable. The following table shows the dates of maximum and minimum of these two classes of phenomena. Column third shows the difference between the dates in the first two columns.

Date of Maximum.			Date of Minimum.		
Solar Spots.	Auroras.	S— A.	Solar Spots.	Auroras.	S— A.
1778	1778	0	1784	1784	0
1788·5	1787·5	+1·0	1798	1798	0
1804	1804·5	−0·5	1810	1811	−1·0
1816·5	1818	−1·5	1823	1823	0
1829·5	1830	−0·5	1833·5	1834·5	−1·0
1837	1840	−3·0	1843·5	1843·5	0
1848·5	1850·5	−2·0	1856	1856	0
1860	1859·5	+0·5	1867	1867	0
1870	1870·5	−0·5	----	----	----

In only two cases is there any sensible difference in the dates of minimum of the two classes of phenomena. Also in the year 1810 only one aurora was recorded, so that this year presents no real discrepancy in the dates of minimum.

From 1832 to 1835 the number of auroras was quite small, so that for the entire series of observations we may say there is an almost complete identity in the dates of minimum of the two classes of phenomena.

With regard to the dates of maximum there is some discordance, which in 1840 amounts to three years. It is also noticeable that the magnetic curve remained nearly stationary from 1836 to 1838 while the sun-spot maximum was sharply defined, suggesting the idea that the connection between the auroral and magnetic curves is more intimate than between the auroral and sun-spot curves.

The discrepancy in 1850 is apparently due to a double or triple maximum of the auroral curve. The New Haven observations show a maximum in 1848, and another in 1852; the combination of all the observations shows three maxima, viz., in 1848, 1850 and 1852, the greatest frequency being in 1850; that is, there was a prolonged period of unusual auroral displays extending over several years.

A comparison of both maxima and minima indicates that the critical periods of the auroral curve occur a little later than

those of the sun-spot curve and that the auroral maximum is frequently more prolonged than the sun-spot maximum.

If we institute a comparison between the auroral curve and the magnetic curve we shall find the correspondence to be still more remarkable. The following table shows the dates of maximum and minimum of these two classes of phenomena. Column third shows the difference between the dates in the first two columns.

Date of Maximum.			Date of Minimum.		
Magnetic Declination.	Auroras.	M—A.	Magnetic Declination.	Auroras.	M—A.
1777	1778	—1 0	1784	1784	0·0
1787	1787·5	—0·5	1799·5	1798	+1·5
1803	1804·5	—1·5	wanting.	1811	
1817·5	1818	—0·5	1823·5	1823	+0·5
1829	1830	—1·0	wanting.	1834·5	
1838	1840	—2·0	1844	1843·5	+0·5
1848·5	1850·5	—2·0	1856	1856	0·0
1859 5	1859·5	0·0	1867	1867	0·0
1870·5	1870·5	0·0	----	----	----

We perceive that the auroral maximum generally occurs a little later than the magnetic maximum, the average difference amounting to one year; while the time of auroral minimum either coincides with the magnetic minimum or slightly precedes it, the average difference amounting to about half a year.

On the whole there seems to be no room for question that the number of auroras seen in the middle latitudes of Europe and America exhibits a true periodicity, following very closely the magnetic periods but not exactly copying them. In particular we notice that during those periods in which the range of the magnetic declination was unusually small, as from 1794 to 1824, auroral exhibitions were extremely few in number and insignificant in respect of brilliancy.

If now we inquire as to the probable connection between these three classes of phenomena, we cannot suppose that a small black spot on the sun exerts any direct influence on the earth's magnetism or electricity, but we must rather conclude that the black spot is a result of a disturbance of the sun's surface which is accompanied by an emanation of some influence from the sun, which is almost instantly felt upon the earth in an unusual disturbance of the earth's magnetism, and a flow of electricity developing the auroral light in the upper regions of the earth's atmosphere. The appearances favor the idea that this emanation consists of a direct flow of electricity from the sun. If we maintain that light and heat are the result of vibrations of a rare ether which fills all space, the analogy between

these agents and electricity would lead us to conclude that this agent also is the result of vibrations in the same medium, or at least that it is a force capable of being propagated through the ether, with a velocity similar to that of light. While this influence is traveling through the void celestial spaces it develops no light, but as soon as it encounters the earth's atmosphere, which appears to extend to a height of about 500 miles, it develops light, and its movements are controlled by the earth's magnetic force, in a manner analogous to the influence of an artificial magnet upon a current of electricity circulating round it.

ART. XXVII.—*Notices of Recent Earthquakes;* by Prof. C. G. ROCKWOOD, Jr., Bowdoin College.

April 3, 1872. "A letter from Beyrout gives some statistics of the earthquake at Antioch in April last.* Before the shock there were 3,003 dwelling houses in the city. Of these 1,960 were ruined, and 894 so damaged as to be uninhabitable, leaving only 149 in good condition. These were besides 1,331 other buildings,—shops, mosques, factories, &c. Of these there are left but 349 shops, one mosque, and one soap factory—so that of the 4,334 buildings of all kinds only 500 are left. The population was about 17,600, of whom 500 were killed and an equal number wounded. In Luedia there were 2,150 houses ruined, and more than 300 persons were killed or wounded."—*Boston Advertiser*, Aug. 13, 1872.

April 24, 1872. Nearly coincident with the eruption of Vesuvius, there was a violent eruption of the volcano Merapi in Java. Streams of lava and boiling water were accompanied by showers of ashes and sand, which obscured the light of the sun, and some 150 persons are reported to have perished. The eruption was attended with slight shocks of earthquake.

June 4, 1872. A slight shock was felt between 10 and 11 P. M. at Chesterfield, Manchester and Ashland, Va., and also at Charlottesville, Va.

June 17, 1872. A sharp shock was felt about 3 P. M. at Milledgeville, Ga. Brick buildings were jarred and windows rattled.

July 8, 1872. A short but distinct shock was felt at 10½ P. M. at Chillicothe, Mo., accompanied by a rumbling noise.

July 11, 1872. A sharp shock was felt at 5.25 A. M. across the southern part of Westchester Co., N. Y. It extended from the Hudson river to and across the western end of Long Island Sound. The area affected would be pretty well covered by a circle described from New Rochelle, N. Y., as a center,

* This Journal, III, iv, p. 4.

with a radius of ten miles. The phenomena are thus described in a letter written from Glen Cove, L. I., to the Smithsonian Institute: "The duration of the trembling motion was about two or three seconds, and its intensity was sufficient to wake almost every one who had not yet awakened. The shock was accompanied by a rumbling noise at the beginning, lasting about one or two seconds; then a tremendous discharge of noise like a violent burst of thunder, at which time the jarring took place; then passing away with the rumbling sound like the passing off of thunder from a violent burst near by. The direction appeared to be from E.N.E. to W.S.W." Other accounts speak vaguely of it as "coming from the south and rolling away off toward the north." At Port Washington, L. I., a clock with a long pendulum was stopped at 26 minutes past 5 A. M. No damage was done anywhere.

August 13, 1872. The eruption of Mauna Loa, in the Sandwich Islands (described in this Journal, III, iv, pp. 331, 406), was attended with earthquake shocks in places near the volcano.

Sept. 7, 1872. Vesuvius was emitting smoke from two craters. Slight shocks were felt at the foot of the mountain.

Sept. 14, 1872. Earthquakes, accompanied by underground explosions, began again in Owen's River valley, Inyo Co., Cal.

Sept. 15, 1872. A severe shock was felt at Yokohama, Japan.

Sept. 21, 1872. A slight shock was felt in the afternoon at Shanghae, China, lasting several seconds.

Sept. 28, 1872. A smart shock was felt at Lima and neighboring towns in Peru.

Oct. 2, 1872. A shock of three seconds' duration was felt in the morning at San Francisco, Cal.

Oct. 9, 1872. A severe shock was felt about 10 A. M. at Sioux City, Iowa, and at Yanctou, Fort Randall, and other points in Dakota. At Sioux City its duration was "twenty or thirty seconds." Though distinctly felt on the low grounds, it was not noticed on the bluff. At Fort Randall it was more severe, and at White Swan, Dak., it was accompanied by a sound like distant thunder.

Oct. 12, 1872. A severe shock was felt at Oakland and San Francisco, Cal., at 4.9 A. M. The Oakland Transcript of Oct. 14 says: "Persons who were awake at the time all agree that the first motion was a vertical one, and immediately after there was a swaying of the earth, the vibrations being from southeast to northwest, or following the range of hills to the northward of the city. It was felt very severely along their base, but no material damage was done anywhere." At San Francisco there were two shocks of several seconds' duration, with oscillations from east to west.

Oct. 18, 1872. Sharp shocks were felt in many districts of New South Wales.

Nov. 12, 1872. A sharp shock was felt in the night at Austin, Nev. A light shock was felt at Stockton, Cal., the same night. A shock was also felt at Valparaiso, Chili, on the same date.

Nov. 18, 1872. A severe shock occurred about 2 P. M. at Concord, N. H. It lasted about ten seconds. The shock was distinctly heard and was plainly perceptible to persons walking in the streets. The apparent course was from west to east. The shock was felt in adjacent towns and also at Laconia, about thirty miles north.

Nov. 28, 1872. A slight shock was felt at Derby, Eng.

Dec. 1, 1872. Despatches of this date from City of Mexico state that shocks had been felt in the district of Michoacan, that a new volcano was forming and eruptions were frequent. Previous letters from Gaudalaxara say that since the end of March last the volcanoes of Colima and Soborneo had shown unusual activity. Loud subterranean sounds were heard, with severe earthquakes and partial eruptions, setting fire to forests and plantations.

Dec. 10 and 11, 1872. Severe shocks were felt at Helena and Deer Lodge, Montana.

At Helena, at 4½ P. M. Dec. 10, there were two shocks of about equal force and duration, the two lasting five seconds. The direction of the wave was from west to east, and it was accompanied by the usual rumbling noise. The vibration was sufficiently forcible to crack plastering, part stove pipes, &c. At 7 A. M. Dec. 11, there was another shock nearly as forcible as the first, but no sound was heard.

At Deer Lodge, which is separated from Helena by a range of mountains, the first shock was at 4.58 P. M. and the last at 6.55 A. M., and there was a slight shock between 2 and 3 o'clock A. M. Here also the wave was from the west or a little north of west and the rumbling noise was heard. It was rather more forcible than at Helena, and was more noticeable on the lowlands than on the bench land. At the time of the first shock it was perfectly calm, the sky one-third cloudy, thermometer +21°, barometer 25·814 in. The shocks were felt at other places in the same valley.

Dec. 14, 1872. A slight shock was felt along the Columbia river in Oregon and Washington Territory. The time is variously reported from 9.20 to 9.40 P. M. At Portland it lasted about 15 seconds. At Dalles there were four or five shocks, and another at 9 A. M., Dec. 15. At Umatilla there were three shocks. At Walla-Walla two heavy shakes. At Wallula a heavy shock, followed by five lighter ones at intervals of 15 minutes, after which a heavy rumbliug sound was heard, and slight shocks continued at irregular intervals until 4 A. M.

Dec. 15, 1872. A shock was felt at various places near Puget Sound, W. T.

At Seattle the time is reported at 11.40 P. M. There were three series of shocks, the first of about two minutes duration, and the other two soon after, and of a few seconds each. The direction of the wave was from northeast to southwest.

At both Victoria and Olympia the time is stated as 9.37 P. M., and the direction from east to west at the former, and from southeast to northwest at the latter. The intensity at each place was sufficient to crack windows and ceilings.

It is uncertain, from the information at present received, whether this may not have been the same with the one of the night previous on the Columbia. If the dates given above are correct, there must have been *two* shocks on the night of the 15th, at 9.37 and 11.40 P. M.

Dec. 26, 1872. A shock of 40 seconds duration was felt at Arequipa, Peru.

Dec. 28, 1872. A severe earthquake, incidental to an eruption of the volcano of San Vicente, damaged the church and houses in the town of Chinameca, San Salvador.

Dec. 31, 1872. A slight shock occurred at Kingston, Jamaica.

Jan. 11, 1873. A slight shock was felt about 5 A. M. at Brunswick, Me., and other places in the State.

Jan., 1873. The *Boston Daily Advertiser* of Jan. 14, has the following:

"London, Eng., Jan. 13. A dispatch from Bombay says a report reached that city that a terrible earthquake occurred at Soonghur, a town of India, in a detached district of the Barada Dominions, 114 miles north of Bombay. Fifteen hundred persons are said to have been killed in the town alone."

Feb. 1, 1873. A severe earthquake occurred in the Island of Samos. It continued four days, and caused much destruction of property and loss of life.

Feb. 2, 1873. A light shock was felti n San Francisco, Cal., and vicinity, at 3½ P. M., lasting about five seconds.

Feb. 3, 1873. A light shock was felt at San Francisco, at 3 P. M., and was quite severe at San Jose and Santa Clara.

Feb. 22, 1873 A shock was felt at Eastport, Me., at 7½ A. M.

The above accounts have been gathered from various newspapers, and, where it was possible, they have been verified by consulting the papers published at the places affected. The time, when given by even hours or half hours, is necessarily only approximate.

Brunswick, Me., March 4, 1873.

ART. XXVIII.—*On some points in Dynamical Geology;* by T. STERRY HUNT, LL.D., F.R.S.

IN his late essay on *The Formation of the Features of the Earth's Crust*, in this Journal for November and December, 1872, Prof. Joseph LeConte has discussed a wide range of subjects in geological dynamics, in a manner for which the geological student cannot but be grateful. After a consideration of the arguments with regard to the nature of the earth's interior, he arrives at the conclusion, that "the whole theory of igneous agencies—which is little less than *the whole foundation of theoretic geology—must be reconstructed on the basis of a solid earth;*" a conclusion which forms the starting point of his essay. It is here to be noted, that the late William Hopkins, to whom we owe one of our great arguments in favor of a solid globe, did not take this ground, but sought to explain the phenomena of igneous action by the hypothesis of portions of matter still remaining unsolidified at no great depth between the solid nucleus and the superficial crust. Dissenting from this view, though accepting the general conclusions of Hopkins and others as to a solid globe, I have been endeavoring, since 1858, to reconstruct, in the language of Prof. LeConte "*the theory of igneous agencies on the basis of a solid earth.*" Alone up to this time, so far as I am aware, I have labored to expand, complete and give geological and chemical consistency to the suggestion long since put forth, both by Keferstein and by Sir John Herschel, that the deeply-buried and water-impregnated strata between the superficial crust of the earth and the solid nucleus constitute a region "of plastic material adequate to explain all the phenomena hitherto ascribed to a fluid nucleus," since "any changes in volume resulting from the contraction of the (solid) nucleus, would affect the outer crust through the medium of the more or less plastic zone of sediments precisely as if the whole interior of the globe were liquid."

A softening by heat of previously solid porous sediments, filled with water, was maintained (in accordance with the views of Babbage as to the rise of the isogeothermal horizons from the deposition of newer strata,) to depend upon the accumulation of large thicknesses of sediment, the results of which were declared to offer a "*ready explanation of all the phenomena of volcanoes and igneous rocks.*" This relation of volcanic phenomena to great accumulation, and those of recent times to more modern sedimentary deposits, which was also maintained by me, was subsequently insisted upon and enforced by Prof. James Hall in the introduction to the third volume

of the Paleontology of New York. A summing up of these views as put forth by me in the Canadian Journal in March, 1858, and in the Quarterly Geological Journal for November, 1859, will be found in this Journal for May, 1861 * (II, xxxi, 411). In this last it was shown, in opposition to the notion of Babbage (who had speculated upon the *expansion* and consequent *elevation* of the deeply buried strata by heat) that one of the effects of heat and water upon the buried sediments would be *condensation*, from the diminution of porosity and still more from the conversion of the earthy materials into crystalline species of higher specific gravity, thus causing *contraction* of the mass. A further and very important result of this accumulation there pointed out was by the softening of the underlying floor, or the "*bottom strata to establish lines of weakness or of least resistance in the earth's crust, and thus determine the contraction which results from the cooling of the globe to exhibit itself in those regions, and along those lines where the ocean's bed is subsiding beneath the accumulated sediments.*" Hence, I added, "we conceive the subsidence invoked by Mr. Hall, though not the sole nor even the principal cause of the corrugations of the earth's strata, is the one which determines their position and direction by making the effects produced by the contraction, not only of sediments but of the earth's nucleus itself, to be exerted along the lines of greatest accumulation." As farther results of this process of accumulation, I also asserted "the metamorphism of sediments *in situ*, their displacement in a pasty condition from igneo-aqueous fusion as plutonic rocks, and their ejection as lavas, with attendant gases and vapors." [Quart. Geol. Jour., Nov., 1859.]

With these conclusions, enunciated in 1858–1861, we may compare those arrived at by Prof. LeConte in his recent essay, where he recognizes as consequences of the heating of great thicknesses of sediments accumulated along the shores of a continent, a process of *condensation* in the lower strata, resulting in "contraction and subsidence *pari passu* with the deposit," followed by "aqueo-igneous softening or even melting, not only of the lower portion of the sediments themselves, but of *the underlying strata upon which they were deposited;* the subsidence probably continues during this process. Finally, this *softening determines a line of yielding to horizontal pressure*, and a consequent upswelling of the line into a chain. Thus are accounted for first, the *subsidence*, then the *subsequent upheaval*, and also the *metamorphism* of the lower strata." Beneath every great line of sediments there will moreover be found, according to him, a reservoir of sedimentary material in a state of more or

* See also, On the probable seat of Volcanic Action, this Journal, II, l, 21, and Geol. Mag., June, 1869.

less complete fusion, in which volcanic phenomena have their seat. The reader cannot fail to see that these views are identical with those which I have so long advocated.

The views of Prof. James Hall as to the relation between great accumulations of strata and mountain-elevations, are cited with approval by LeConte, who, following him, asserts that "mountain chains are masses of immensely thick sediments." I venture, however, to remark, in this connection, that the views both of Mr. Hall and of myself, as his expounder, have as yet been but imperfectly understood either by LeConte or our other critics. Thus they have been defined as "a theory of mountains with the origin of mountains left out;" while LeConte says, "Hall and Hunt leave the sediments just after the whole preparation has been made, but before the actual mountain-formation has taken place." Now, in fact, so far as I am aware, neither Hall nor yet myself in my exposition of his views, which will be found in this Journal for May, 1861 [II, xxxi, 406–410], has proposed any theory to explain this latter part of the process, that is to say, the uplifting of the deposited sediments, which LeConte calls "the actual mountain-formation." Hall's contribution to the problem, which, as our author well says, forms "an era in geological science," was to show the relation between mountain chains and great accumulations of sediments, to illustrate this by the history of the Paleozoic rocks of North America; and moreover to protest against the generally received theory that mountain elevations are due to local upthrusts; he, to use his own language, "going back to the theories long since entertained by geologists relative to continental elevations." That mountains were the remnants of eroded continental areas had already been taught by Lesley, and long before by Buffon and DeMontlosier. It was left for Hall, through a new way, to lead us back to these views; but the whole theory of the cause of continental elevations was left by him where he found it. In my exposition of his views, I have only endeavored, in addition, to show in what manner a contracting globe and a solid nucleus may be related to the great facts of local subsidence and accumulation.

I shall not attempt to follow LeConte in his objections to the views of Dana and Whitney with regard to the uplifting of mountains, but proceed to notice briefly his own, according to which the horizontal thrust resulting from the slow contraction of the nucleus is brought, in the manner which I long since explained, to act upon the great accumulations of sediment, so that they are "crushed together horizontally and swelled up vertically," thus producing not only plications and slaty cleavage, but an amount of vertical extension "*fully adequate to account for the upheaval of the greatest mountain*

chains;" the ridges, peaks, gorges and valleys of mountain regions being however the results of subsequent erosion. This theory of the plications of strata, and their relations both to great accumulations and to a contracting nucleus, is fully set forth in my paper of 1861, already quoted; where I have also insisted upon the results of "the lateral pressure brought to bear upon the strata in an elongated basin (of subsidence) by the contraction of the globe." But while admitting that the process here described must cause elevations of the compressed strata, it must be said that it fails to solve the problem of the uplifting of mountain regions, the strata of which have, in many cases, undergone neither folding nor lateral compression, but are nearly or quite horizontal. Foldings, contortions and slaty cleavage, though met with in many mountain regions, are in fact, accidents which are to be left out of view in considering the origin of mountains. The student of physical geography may learn from the great elevated plateaus of the globe, the truth of De Montlosier's statement, that the great mountain chains of Europe are but the remains of continental elevations which have been cut away by denudation, and that the foldings and inversions to be met with in the structure of mountains are to be looked upon only as local and accidental. [This Journal, II, xxxi, 408.] In a similar spirit Jukes remarks that we learn "how completely the present surface of the earth is a sculptured surface carved out by denudation, and how little, as a rule, it is effected by the dislocations, upheavals and convolutions of the rocks beneath it." [Manual of Geology, 3d ed., 449.] In the case of the uplifted paleozoic basin of eastern North America, as Hall has well shown, the process of elevation was the same for the thicker and corrugated sediments of the eastern portion and for the thinner and undisturbed strata of the valley of the upper Mississippi. The hills in the latter region, built up of 1,000 feet of horizontal beds, having the Potsdam sandstone at the base, and capped by the Niagara limestone, show us the production of mountains by erosion, uncomplicated by the accidents which make their study more difficult in regions where contortion of the strata has supervened. Hall has also noted in this connection the nearly horizontal strata of the Cattskill Mountains.

The question of the structure and the origin of the Appalachians has been complicated by the assumption that the crystalline strata which constitute their higher portions are altered sediments of paleozoic age, rather than parts of an ancient continent of eozoic rocks which formed the eastern border of the paleozoic sea, corresponding to the Rocky Mountains on the west. The former view has been very generally held by Ameri-

can geologists, and was maintained by the present writer until 1870, when he endeavored to show that the crystalline rocks of New England and their lithological representatives both to the southwest and the northwest are of pre-paleozoic age, and in part Laurentian. [This Journal, II. l, 83; also Address before the American Association, Indianapolis, 1871.] This view, already before maintained by Credner and by Emmons, is now advocated by LeConte, who conceives that the gneissic region of the Atlantic slope is Laurentian, and was probably "land during the paleozoic times," constituting an "eastern continental mass," which, judging from the immense thickness of sediments in the eastern parts of the paleozoic area, must have been of great extent. A similar view was put forward by H. D. Rogers in 1842, and again by James Hall in 1859, when, after describing these paleozoic sediments, he said, "we may have had a coast line nearly parallel to and co-extensive with the Appalachians" [Paleontology, iii, page 96, note]; commenting upon which, in 1861, I asserted that these coarse sediments "were evidently derived from a wasting continent." In a paper read before the American Geographical Society, New York, Nov. 12, 1872, I adduced a farther argument in favor of such a pre-paleozoic continent to the eastward, from the climatic condition of great dryness which gave rise to the paleozoic region of North America, to deposits of salt, gypsum and dolomite over considerable areas from Nova Scotia to Michigan and Ohio, and from the time of the Calciferous sandrock to that of the Lower Carboniferous. [Engineering and Mining Journal, Jan. 14, and 23, 1873.]

In concluding his essay, Prof. LeConte declares that an important problem in geological dynamics remains, in his opinion, unsolved; viz., the cause of those "great and wide-spread *oscillations* which have marked the great divisions of *time* and have left their impress in the general unconformability of the strata;" the last being that of the post-tertiary period. Now it is precisely the *upward* movements of this kind which constitute the continental elevations of De Montlosier, Hall and myself, giving rise to plateaus, and by the partial erosion and denudation of these to mountains. The cause of these continental elevations was not discussed by Hall, and is by LeConte declared to be unexplained; while such is the case, "the actual mountain-formation," to use his words, is still unaccounted for. That these gentle and wide-spread movements of oscillation are, however, in some way not yet clearly explained, connected with the contracting of the nucleus and the consequent conforming thereto of the envelope, we can scarcely doubt, or that the latter, from its nature and origin, must present great differences in constitution and in flexibility in its various parts.

From this it might be expected that the movements imparted to the envelope alike by the process of secular cooling and contraction of the nucleus, and by the disturbance of the equilibrium of pressure consequent on the processes of erosion and sedimentation would give rise to seemingly irregular oscillations, resulting in the depression or the elevation of considerable areas, constituting continental movements.

The grave question here arises as to whether the heat which plays such an important part in the phenomena under consideration, is a cause or an effect of the activities beneath the earth's surface. Starting from the notion of an igneous center, Babbage and Herschel adopted the first view, in which I have followed them, maintaining that the heat from a yet uncooled nucleus is the efficient cause of all igneous and volcanic manifestations. According to Keferstein, on the other hand, the hypothesis of an incandescent nucleus is unnecessary, and the internal heat results from what he called a fermentation among the deeply buried sedimentary layers. A view which unites these two is proposed by LeConte, who suggests that heat from a central source invading the buried sediments may there excite chemical action, which will, in its turn, evolve heat, and thus greatly augment their temperature. It is, however, I think, probable that any chemical processes which may be set up in the buried sediments for their conversion into igneous rocks and volcanic products would absorb rather than generate heat.

In his remarkable study of the Secular Cooling of the Earth [Trans. Royal Soc. Edinb., xxiii, pt. 1, page 157], Sir William Thomson arrives at the conclusion that the observed mean rate of increase in descending in the earth's crust will continue with but little variation for 100,000 feet, but will gradually diminish at greater depths. Estimating with him the rate of increase at one degree of Fahrenheit for fifty-one feet, it would require the depth just named, or about nineteen miles, to give a temperature of 2,000° F., which may be supposed sufficient to produce the chemical actions required. See my paper on The Probable Seat of Volcanic Action. [This Jour., II, I, 21.] But it is probable that the seat of volcanic activity may be much less profound than above supposed, in which case the central heat would be inadequate. *Chemical* action, as suggested by Keferstein and LeConte, being rejected as a source of heat, there however remained the hypothesis that thermal effects might result from local *physical* causes, and that the immense chemical force exerted in the movements of the earth's crust might be converted into heat. This view was, so far as I am aware, first advanced by Mr. George L Vose,* whose

* As recognized by Prof. LeConte, on page 156, this volume.

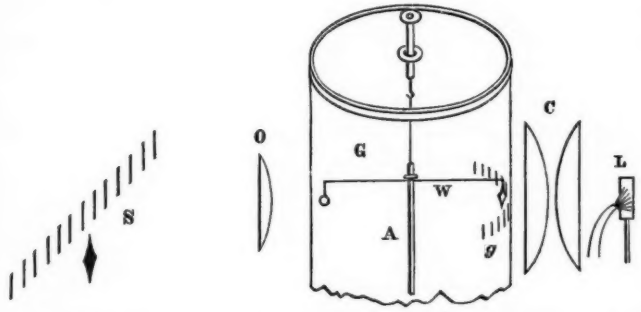
review of Orographic Geology, a most valuable contribution to the literature of the subject, was published in 1866. In it, while recognizing with Sorby the conversion of mechanical force into chemical action, he insists that "the enormous pressure generated in the folding of masses of rocks the depth of which is measured by miles," is an agent potent to produce changes both mechanical and chemical. The causes of the conversion of sediments into plutonic rocks like granite, he conceives to be "*mechanical compression, with the heat and chemical action* which proceed therefrom," and adds in a note, alluding to the view which explains their conversion by the action of heat from beneath, "we should prefer to get the heat needed by the compression which accompanies the disturbance of the strata where metamorphism occurs." [Orographic Geology, pp. 129, 130.] This view of Mr. Vose is confirmed by the late researches of Robert Mallet, who concludes that, "as the solid crust sinks together to follow down the shrinking nucleus the *work* expended in mutual crushing and dislocation of its parts is *transformed into heat*, by which at the places where the crushing sufficiently takes place, the material of the rock so crushed and that adjacent to it are heated even to fusion. The access of water at such points determines volcanic eruption" [this Jour., III, iv, 411]. To this it may be added that, inasmuch as the crushing process takes place in strata which from their depth are already at an elevated temperature, the heat developed by the mechanical process comes in to supplement that derived by conduction from the igneous center. Moreover, these strata include besides water, in many cases the compounds of chlorine, sulphur and carbon necessary for the generation of the various gases which are the frequent accompaniments of volcanic eruption. With the contributions of Vose and Mallet, the theory of volcanic action advocated by Keferstein, Herschel and myself, would seem to be well nigh complete.

Institute of Technology, Boston, Jan., 1873.

ART. XXIX.—*On a simple device for projecting on a screen the deflections of the needles of a Galvanometer, and thus obtaining an instrument convenient in research, and suitable for lecture experiments;* by ALFRED M. MAYER, Ph.D.

THE instrumental problem of obtaining on a screen the deflections of a galvanometer needle in magnified proportions has occupied the thoughts of several physicists. The subject is evidently one of considerable importance. In delicate researches it is often necessary that the body of the observer

should be removed from the instrument, while at the same time he must be able to observe the minute deflections of its needles. In lectures before our college classes many of the most interesting and fundamental phenomena of radiant heat, electricity, and magnetism are generally either entirely omitted, or imperfectly presented, in default of an instrument which can be constructed by anyone at a small outlay of time and expense. The problem, therefore, has not been deemed below the serious attention of eminent investigators; and although there are some who consider such contrivances as trivial, yet I imagine they would think otherwise if they had the habit of continued original investigation, or the proper ambition to address their students in the very language of Nature, by bringing them face to face with those phenomena which form the sure foundation of our scientific reasoning.



The method, invented by Poggendorff, of observing the deflections of the galvanometer by reflecting to a screen a beam of light from a small mirror attached to the needles, has been used for many years. Sir William Thomson and Prof. Tyndall have extensively used this method; and it has the advantage of giving to the reflected beam an angular motion the double of that given to the mirror by the needles. More recently Tyndall has devised an instrument based on the principle of the megascope. He throws a vertical beam from an electric lamp on to the dial and needle of the galvanometer, and by means of a lens and inclined mirror, placed above them, he obtains their images on the screen. In the number of this Journal for June, 1872, I published "A new form of Lantern-Galvanometer," which was subsequently republished in the L., E. and D. Phil. Mag., and in Dr. Carl's "Repertorium." This instrument, although it served admirably in the experiments for which it was specially devised, yet is of difficult construc-

tion and of limited applications when compared with the very simple apparatus I will now proceed to describe.

G is the glass shade of the galvanometer, on which, at *g*, are drawn in india-ink the vertical graduation lines of the instrument. A is a piece of aluminum wire to whose lower end are fixed the needles of the galvanometer, and whose upper end is perforated with a small hole so that the system may be suspended by a silk fiber. A fine wire of german-silver, *w*, is attached transversely to the aluminum wire, and has its ends bent downward at right angles to its length. This transverse wire can be placed at any azimuth by rotating it around its center, which is coiled two or three times around the vertical aluminum wire. On one of the bent ends of the transverse wire is cemented a diamond-shaped piece of light paper or foil, and the other end carries a small ball of wax, whose weight equals that of the piece of paper or foil. The diamond courses around the shade at about one millimeter from its interior surface, with its lower point just above the lines of graduation. At C are represented the condensing lenses of an oxhydrogen lantern, whose jet and lime are at L. O is the objective which gives on the screen the magnified image of pointer and scale, as seen at S. This scale is not graduated into equal angular divisions, but its units represent units of deflecting force traversing the galvanometer; and this scale is derived from a careful calibation of the instrument.

The sharpness of the image on the screen is admirable, and with the calcium light is distinctly visible in a room considerably illuminated with daylight. With less illumination of the room I have used the instrument when the calcium light was replaced by a kerosene flame.

Evidently the precision of the indications of the apparatus just described are vitiated by the parallax of the index, for it does not describe a cylinder which is an extension of the one on which are drawn the graduations. This error is avoided by cementing on the inside of the shade a curved piece of glass whose radius of curvature equals the arm carrying the index, and whose center coincides with the axis of the aluminum wire. With this modification in the apparatus we have succeeded in reading with precision deflections to 6′ of arc.

By the following arrangement deflections to 1′, in an arc extending 5° each side of the 0° point, can be determined. A thin slip of microscope cover-glass is coated with a layer of black varnish, and through this varnish are cut, in a dividing engine, fine equidistant lines. The diamond-shaped pointer is replaced by a light piece of cover-glass, also coated with varnish, and having cut on it one fine vertical line. These lines are illuminated by the lantern, and in front of them is

placed an inch or an inch and a half objective. On the screen we have the graduations as a series of bright lines on a dark ground, and along them moves the bright index line of the pointer.

The zero points of the scales can be brought accurately to coincide with the normal position of the index by revolving the shade on its base; and by turning the transverse wire so that it points toward the screen, when the needles of the galvanometer have come to rest, we can readily project the image of the pointer and scale in any desired direction.

Although there are some advantages in having the scales attached to the galvanometer, and in obtaining on the screen their magnified images; yet, we can save much time in the construction of the apparatus by substituting for them scales drawn directly on the screen in very black india-ink.

My experience with this instrument has led me to prefer the use of only one magnetic needle—the one enclosed in the coil of the galvanometer—and this needle I render more or less astatic by means of a damping magnet placed above the galvanometer and sliding on a vertical rod and rotating on its center around the same. By means of the magnet, one can, with expedition, adapt the sensitiveness of the instrument to the requirements of special experiments, and thus the instrument is admirably suited for all experiments in radiant heat, electricity or magneto-electricity. In fact, on holding my hand at a distance of 15 centimeters from the face of a thermo pile, without its conical reflector, I have often deflected the needle 30°.

One might suppose that the heat from the source of light would cause currents of air in the shade and make the needle fluctuate; but I have not met with this difficulty, and if it should arise it can be removed by placing in front of the condensing lenses a glass tank containing a solution of alum.

The evident superiority of this instrument in simplicity of construction over all preceding devices will at once commend it; indeed, anyone in an hour or so can convert his galvanometer into a more convenient and precise instrument for research, and for the illustration of phenomena which have heretofore been presented to students only with considerable trouble on the part of the professor. Now, however, the whole of the beautiful phenomena of radiant heat, which require a delicate instrument for their evolution, can be exhibited with ease and pleasure before our college classes.

December 31st, 1872.

ART. XXX.—*Investigations on Parasulphobenzoic Acid;* by IRA REMSEN.

(Continued from page 186.)

III. *Formation of Parasulphobenzoic Acid from Sulphotoluenic Acid.*

WHEN substituting agents are allowed to act upon toluene, in the case of derivatives containing one substituting group, two products are formed. These are the para- and ortho- varieties. The former is always produced in much larger quantity than the latter. This has been proved by Engelhardt and Latschinoff,* and by Wolkow,† in the case of the sulpho-derivatives. Wolkow proved that the products belonged to the para- and ortho-series by converting them respectively into paraoxybenzoic and salicylic acids. According to the experiments of the chemists mentioned, the two sulpho acids can be separated by partial crystallization of the potassium salts. In this way the parasalt was obtained in a perfectly pure condition, while the ortho-salt could not be freed entirely from the para-salt.

Now, as it had been shown that the oxidation of the monobrom- and mono-chlor-derivatives of toluene yielded corresponding derivatives of benzoic acid, the idea naturally suggested itself that similar treatment of sulphotoluenic acid might yield the desired derivative of benzoic acid. My best hopes were satisfied. After a few experiments it became evident that by means of this reaction I could prepare parasulphobenzoic acid in unlimited quantity with but comparatively little labor.

The principal difficulty that presented itself was to be looked for in connection with the fact that the sulpho-acid is exceedingly easily soluble; and some method had to be devised to extract it from the oxidizing mixture, provided it were formed. A preliminary experiment made with a small quantity of the potassium salts of the sulphotoluenic acids showed that they were easily acted upon by a mixture of sulphuric acid and potassium bichromate. Taking advantage of the suggestion of Fittig,‡ with the hope that the ortho-acid would be destroyed by the oxidizing agents, I subjected the mixture of the two potassium salts to the influence of sulphuric acid and potassium bichromate in noted proportions. The oxidation, when once commenced by gently heating over a water-bath, proceeds rapidly to the end without the further aid of heat, and is com-

* Zeitschrift für Chemie, N. F. 5, 615.
† Ibid., N. F. 6, 321.
‡ Zeitschrift für Chemie, N. F. 7, 179.

pleted in the course of a few minutes. The liquid becomes very hot and foams somewhat; an evolution of gas takes place as long as the oxidation-process continues; and its cessation indicates the end of the operation. In order to extract the product from the mixture the whole was diluted with a large amount of water, and chalk added to the point of neutralization. By this means the chromium oxide formed, and the excess of sulphuric acid were precipitated, and in the solution remained the potassium salts of the sulpho-acid or acids, together with some neutral potassium chromate. Baryta-water was now added in sufficient quantity to precipitate exactly the chromic acid present, this filtered off, and the filtrate evaporated almost to dryness. The colorless residue consisted of the potassium salts together with some potassium hydroxide. The mass was first neutralized with sulphuric acid, and then a sufficient quantity of the latter added to set the sulpho-acids free, care being taken to avoid any large excess. Moderately strong alcohol being now poured upon the mixture, an abundant deposite of ptassium sulphate took place. This was filtered off, the salt well washed out with alcohol, and the alcoholic filtrate evaporated down again to a small volume. Potassium sulphate was again deposited. This was filtered off, washed out, etc., and the operation repeated a few times. Finally the alcoholic solution was boiled for some time with water, and then evaporated to dryness over the water-bath. In this way the sulpho-acids were obtained in a free state without impurities. The acid barium salts were prepared, and, on bringing their solution to the point of crystallization, large acicular crystals were at once deposited, and these possessed the characteristics of the acid barium salt of parasulphobenzoic acid already described. They were analyzed with the following results:

0·5415 grams salt were heated above 200°, and lost 0·0495 grams H^2O; and gave 0·2130 grams $BaSO^4$=0·12524 Ba.

	Calculated.		Found.
($C^{14}H^{10}S^2O^{10}$)	402	67·79	
Ba	137	23·10	23·13
$3H^2O$	54	9·11	9·14
	593	100·00	

This shows then conclusively that by the oxidation with sulphuric acid and potassium bichromate, the sulpho-group of parasulphotoluenic acid remains intact. The conduct of the ortho-acid under like circumstances I shall refer to below. As far as I have been able to discover by a consultation of the literature, this is the first attempt which has been made to oxidize sulpho-acids in the manner described. The simplicity of

the reaction and the satisfactory character of the results lead me to desire the further application of the principle involved, and I shall take the first opportunity to prepare a pure sulphoxylenic and sulphosmesitylenic acid with the object of subjecting them to the influence of oxidizing agents, hoping thus to obtain an *oxybibasic* and an *oxytribasic* acid.

After having gained the necessary preliminary knowledge, I proceeded to determine the best conditions for the reaction. A large number of experiments were made, and as the result I would give the following directions: Instead of first preparing the potassium salts of the sulphotoluenic acids, I employed a solution of the acids in sulphuric acid, considerable labor being thus saved. 25 grams of pure toluene are dissolved in 200 grams of fuming sulphuric acid without the aid of heat. When this solution has cooled down somewhat, two volumes of water are added and the height of the liquid in the flask marked. Now more water is added, and the mass subjected to distillation until the liquid has reached the original volume indicated by the mark on the vessel. In this way any toluene which may have remained unacted upon by the sulphuric acid is removed. The solution is now allowed to cool to the ordinary temperature, and then 160 grams of coarsely powdered potassium bichromate gradually added. In order to start the oxidation the flask is placed on a water bath, and gently heated for about ten minutes. During this time a commotion is noticed in the liquid which gradually increases. An active foaming ensues, and when this has fairly begun, the flask is removed from the water-bath. A uniform evolution of gas continues until the end of the operation, which occupies usually about twenty minutes in all. The gas evolved is carbonic acid, as was proved by appropriate reactions. In heating the mixture at first, it is absolutely necessary to place it on a water-bath; if the attempt be made to heat with a flame the flask invariably breaks. This is occasioned by the fact that the potassium bichromate lies at the bottom of the flask; and that the oxidation commences and goes on rapidly just at the spot where the heat from the flame is strongest. This spot immediately becomes very hot before the remainder of the glass has been at all heated, and from this spot a circular piece of glass inevitably drops, followed by the contents of the flask. When the operation is at an end, which, as stated, is indicated by the cessation of the evolution of gas, the whole is diluted with water, and then treated successively, as above described, with chalk, baryta-water, sulphuric acid and alcohol. By this method in the course of a few days a very large quantity of pure acid barium parasulphobenzoate can be prepared.

Parasulphobenzoic Acid, $C^6H^4\begin{cases}SO^2.OH\\CO.OH\end{cases}$, is prepared from the barium salt by precipitating the barium exactly with pure sulphuric acid, and evaporating the solution. It is very easily soluble in water, and crystallizes from a very concentrated solution in the form of beautiful, colorless, transparent needles. These, though very easily soluble, are not deliquescent. They fuse above 200°, but undergo decomposition before the fusing point is reached. The meta-acid is deliquescent.

Potassium Parasulphobenzoate, prepared by neutralizing and precipitating the acid barium salt by means of a solution of pure potassium carbonate, is exceedingly easily soluble in water, but crystallizes finally in well-formed, transparent needles.

Acid sodium parasulphobenzoate, $C^6H^4\begin{cases}SO^2.ONa\\CO.OH\end{cases}+2\frac{1}{2}H^2O$. This salt was prepared by neutralizing and precipitating the acid barium salt with sodium carbonate, and then adding hydrochloric acid to the solution, evaporating and allowing to crystallize. It forms beautiful, long, colorless, lustrous, stellate prisms. It is moderately easily soluble in cold water, more easily in hot water. The corresponding salt of the meta-acid is more difficultly soluble in cold water, and crystallizes in laminæ. The two, when present in the same solution, can not, however, be separated. The analysis of the salt gave the following results:

0·3707 grams of the salt, dried over sulphuric acid, on being heated gradually to 310°, lost 0·0607 grams in weight; and then gave 0·102 grams Na^2SO^4=0·033038 grams Na.

	Calculated.		Found.
($C^7H^5SO^5$)	201	74·72	
Na	23	8·55	8·91
$2\frac{1}{2}H^2O$	45	16·73	16·37
	269	100·00	

The remarkable fact will be noticed that the water of crystallization is not driven off entirely until a high temperature (320°) is reached. All other salts of this acid, as well as of the meta-acid, which contain water of crystallization, exhibit the same property, though not in such a marked degree as this one.

Barium parasulphobenzoate, $C^7H^4SO^5.Ba+2H^2O$. This salt was obtained by neutralizing a solution of the acid salt with barium carbonate. It is moderately easily soluble in cold water, very easily in hot water. It crystallizes in small needles, which are grouped together in verrucous masses. The corresponding salt of the meta-acid is also easily soluble in water,

but according to the descriptions given it contains no water of crystallization.

The analysis resulted as follows:

0·4174 grams salt, dried over sulphuric acid, on being heated gradually to 190°, lost 0·0411 grams H^2O; and then gave 0·2587 grams $BaSO^4$=0·15212 grams Ba.

	Calculated.		Found.
$C^7H^4SO^5$	200	53·62	
Ba	137	36·73	36·44
$2H^2O$	36	9·65	9·84
	373	100·00	

Acid barium parasulphobenzoate, $(C^7H^5S^2O^5)^2Ba+3H^2O$. The methods of preparation and analysis of this salt have already been given in detail. It is by far the most characteristic salt of parasulphobenzoic acid; and its properties are such as to render its preparation in an absolutely pure condition very simple. It is exceedingly difficultly soluble in cold water, When perfectly pure the length of the crystals is only dependent upon the depth of the liquid in which they are formed. It is more difficultly soluble, both in cold and in hot water, than the meta-salt. Like the meta-salt it does not give off its water of crystallization entirely below 200°; and it may be subjected to a much higher temperature without the danger of decomposition.

Calcium parasulphobenzoate is an amorphous powder which is somewhat more easily soluble in cold water than in hot, and is hence thrown down when a concentrated cold solution is boiled.

When the potassium salts, obtained in the preparation of acid barium parasulphobenzoate by evaporating the solution which has been treated with chalk and baryta-water, are fused with potassium hydroxide, a mixture of paraoxybenzoic and salicylic acids is obtained, the salicylic acid forming in some cases fully half of the product. This fact taken alone led at first to the conclusion that the methyl groups of both the para- and ortho-sulpho acids had been oxidized; and that thus not only parasulphobenzoic acid had been formed, but at the same time orthosulphobenzoic acid. Further investigation, however, showed conclusively that this was not the case, but proved another interesting fact, of which I shall speak below.

IV. *Formation of Terephtalic Acid from Parasulphobenzoic Acid.*

The recent experiments of V. Meyer* have tended to materially modify the prevalent views in regard to the constitution

* Berliner Berichte, III Jahrgang, 112; and Annalen der Chemie u. Pharmacie, clvi, 265.

of the biderivatives of benzene. Meyer showed that ordinary sulphobenzoic acid, which, on the one hand, could be converted into oxybenzoic acid, could, on the other hand, be converted into isophtalic acid by fusing its potassium salt with sodium formate. As, according to the reigning ideas, isophtalic acid can only have the constitution indicated by the 1·3 position of its carboxyl groups, it became evident that oxybenzoic acid, which up to that time had been looked upon as belonging to the same series as phtalic acid, viz: the ortho (1·2) series, in reality belonged to the meta (1·3) series, of which isophtalic acid is the most satisfactory representative. Salicylic acid thus became the 1·2 oxybenzoic acid, and the formulæ of a number of compounds were subsequently changed of necessity to place them in concordance with the results of the above reaction. But to take thus one experiment as the basis of a change as serious as that which ensued was looked upon by some chemists as insufficient; and, indeed, Meyer himself, in his first notice* on this subject, says: "Bei allen Schlüssen, die wir aus Reactionen, wie die oben beschriebene, ziehen, mahnt freilich die von Kekulé beobachtete Thatsache, dass die Phenolsulfosäure mit Leichtigkeit aus der Meta-Stellung in die Para-Stellung übergeht, zu grosser Vorsicht und ich werde daher auch die so eben aufgestellte Reihe nicht für völlig bewiesen halten, bevor ich nicht auch ein Glied der Meta-Rahe in gewöhnliche Phtalsäure werde übergeführt haben." Notwithstanding the fact that a great number of experiments were made with the object of more firmly establishing the principle adopted, by converting a member of the other series into the corresponding bibasic acid, they all failed; and the two analogous experiments of Meyer, viz.: the conversion of sulphobenzoic acid into isophtalic acid and the conversion of bromobenzoic acid into isophtalic acid, remained without support in their testimony. Attempts to apply the reaction to other fields were also unsuccessful, as shown in the experiments of Barth† and Ascher.‡ It is hardly strange then that, with these circumstances, the changes proposed by Meyer were not universally accepted; and those who opposed them on the ground that molecular rearrangement might here play a role were certainly to some extent justified.

As I was now in possession of the para-acid§ corresponding to the meta-acid‖ with which Meyer performed his experiment, it became an interesting question as to what the conduct of this compound would be when fused with sodium formate.

From the pure acid barium salt the potassium salt was prepared and, the directions of Meyer being closely followed, this

* Berliner Berichte, 1II Jahrgang, 112. † Berliner Berichte, IV Jahrgang, 634.
‡ Annalen der Chemie u. Pharmacie, clxi, 3.
§ Para 1·4. ‖ Meta 1·3.

salt was fused with an equal weight of pure sodium formate. In order to bring the mass to the point of fusion a comparatively high temperature was required. It then remained in a semi-liquid condition, apparently evolving gas for a short time, finally becoming much darker in color—in fact nearly black. At a certain point volatile products, evidently containing sulphur, were given off, the odor of which was intensely disagreeable. The operation was performed in a silver crucible; and the mass constantly stirred with a silver spatula. Occasionally the vapors which were given off took fire above the crucible, and, on the gas-flame being now removed from beneath, and the flame of the burning vapor being extinguished, the mixture continued red-hot for a short time, presenting the appearance of a burning coal. When all had cooled down to the ordinary temperature the crucible and contents were placed in water, and this boiled. The solution thus obtained was filtered and, when cold, was treated with sulphuric acid. Thus was thrown down a very voluminous, flocculent precipitate of a decidedly dark color. In order to purify the product, it was filtered off and well washed out with hot water; then dissolved in ammonia, and this solution boiled with animal charcoal. A nearly colorless solution resulted, and on treating this with sulphuric acid the precipitate formed was almost white. An attempt was made to prepare the barium salt by boiling with pure barium carbonate. After long continued boiling with a large amount of water the acid had disappeared and the salt was in solution. On evaporating gradually the salt was deposited in crusts during the process. It proved to be of exceedingly difficult solubility in water, boiling as well as cold. A small portion of it appeared to have a tendency to crystallize. This was separated from the powder and crusts, and repeatedly recrystallized. It was also very difficultly soluble in water, and yielded an acid which resembled terephtalic acid in some properties. By means of various reactions, however, it was soon proved that this was not one of the phtalic acids, and it seemed probable that it might represent a variety of the thihydrobenzoic acids, the formation of which has been shown* to take place in the reaction of Meyer for the preparation of isophtalic acid. The amount of the substance obtained was not sufficient to permit of its close examination, its perfect separation from the other substance formed being impossible. The difficulty of separation threatened at the outset to be a serious obstacle in the way of deciding the point under consideration. One method after another was tried; but the results were decidedly unsatisfactory; until finally the mixture was subjected to the influence of an oxidizing agent (sulphuric acid and potassium bichro-

* Ador, Berliner Berichte, IV Jahrgang, 622.

mate). By this means the thihydrobenzoic acid (?) was so changed in character as to become soluble, whereas the other constituent of the mixture was left behind in a pure condition unacted upon. It was dissolved in ammonia, reprecipitated by means of a strong acid, filtered and well washed out. In this condition it had the form of a very light, flocculent, white mass. It could be dissolved in boiling alcohol, and from this solution it was obtained in the form of microscopic needles which were deposited upon the sides of the vessel. This substance could not be brought to fusion. When heated in a capillary tube it sublimed from one part to the other before the flame; and was finally decomposed without fusing. It was almost absolutely insoluble in water, both boiling and cold; insoluble in ether. The pure substance could not be perfectly dissolved by boiling with barium carbonate. A small amount of the barium salt of the acid was, however, thus obtained, and this was very difficultly soluble in water and did not crystallize. The calcium salt resembled this in every way.

These are the properties of terephtalic acid, with the exception of the conduct toward alcohol. To this I am not inclined to attach much weight, as the acid which is described as insoluble in alcohol is that which is obtained by oxidation of xylene, and the *condition* of this acid differs essentially from that of the light mass obtained by precipitating it from one of its salts. Further, I found that after being dried, the acid, as obtained by me, was also insoluble in alcohol. I would hence rather consider this conduct as indicating a property of terephtalic acid which had been overlooked. The substance was proved to have the composition of terephtalic acid by the following analysis:

0·2325 grams substance, dried over sulphuric acid, gave 0·4897 grams CO^2 = 0·13355 grams C and 0·0832 grams H^2O = 0·00924 grams H.

	Calculated.		Found.
C^8	96	57·83	57·44
H^6	6	3·61	3·97
O^4	64	38·56	
	166	100·00	

The proofs that terephtalic acid is formed when potassium parasulphobenzoate and sodium formate are fused together are thus conclusive. It remained, however, to show that neither phtalic nor isophtalic acid was formed at the same time. The crude product was boiled with water for a long time and then filtered off. On allowing the filtrate to cool a small quantity of substance was deposited in the form of powder. The whole was shaken with ether, which dissolved the powder and extracted whatever might be in solution. The original solution from

which the crude acid had been precipitated was also treated with ether. On uniting the ethereal solutions and distilling off the ether, a residue was obtained which dissolved readily in alkaline carbonates. It was neutralized with barium carbonate. The barium salt was easily soluble and crystallized well. The free acid separated from this salt was easily soluble in hot water and crystallized out on cooling. It had the fusing point 120° and all the other properties of *benzoic acid*. No other substance could be found. The quantity of benzoic acid obtained was very small in comparison to the whole quantity of the product; and its formation can easily be accounted for when we consider the character of the reaction.

Here then, at least, no molecular rearrangement takes place; and this, taken in connection with Meyer's experiment, certainly makes the case strong enough to command attention. The reaction is thus shown to be capable of application for the purpose of determining the constitution of compounds; and the changes proposed by Meyer can be demanded with greater confidence than before. The proofs that paraoxybenzoic and terephtalic acids belong to the same series had already been given* by other reactions; though, acknowledging the described reaction, this would be the most direct proof of the fact.

(To be continued.)

ART. XXXI.—*Note on the Age of the Metamorphic Rocks of Portland, Dodge county, Wisconsin;* by ROLAND D. IRVING, E.M., Professor of Geology, Mining and Metallurgy, in the University of Wisconsin.

IN an Article on "The Age of the Quartzites, Conglomerates and Schists of Sauk County, Wisconsin," published in this Journal for February of the present year (1872), I gave what I believe to be ample proof of the Pre-Potsdam age of the rocks then treated of. These rocks, previously regarded by good authority (Winchell, Eaton, Percival), as having resulted from a metamorphism of the Potsdam sandstones, I then showed to have been outlying islands and reef ledges in the Potsdam seas. I stated also that there were several other outlying patches of metamorphic rocks, similar to these, and scattered at wide distances apart within the Lower Silurian area; one of these I have since been able to examine with some care, and am prepared to say of the rocks found there what I did of those in the Sauk county region, viz: that they are undoubtedly Pre-Potsdam. The locality referred to is near the village of Portland, in the

* See V. Meyer, Annalen der Chemie u. Pharmacie, clvi, 267.

S.W. corner of Dodge county, at least thirty-five miles from the Sauk county metamorphic rocks, and fully eighty-five miles from the nearest point of the main Azoic body of the northern portion of the State.

I have ascertained, I think, all that has heretofore been published about this locality. The first public announcement seems to have been made by Dr. I. A. Lapham in a lecture at Milwaukee in February, 1848. He there speaks of the rock as just discovered and as "primitive rock." This lecture afforded Dr. Owen the data for the foot-note which I find on page 151 of Owen's Report on Wisconsin, Iowa and Minnesota (1852), and from which I take the following: "The late Mr. J. S. Thayer observed a locality of *granite* in Dodge county, Wisconsin, on the west branch of Rock river, on Section 33, Township 9 north, Range 13 west." The only other reference I am able to find occurs in the Report of Progress of Dr. James G. Percival for 1855. On page 101 of that report I find a heading, "The Quartz Rock of Baraboo and Portland." The first sentence under this head reads as follows: "The quartz rock in the ridges adjoining the Baraboo valley, on the north and south, and that east of Portland, are so similar in character that they may be considered in connection." He further states that the Baraboo (Sauk) quartzites are changed "Lower" or Potsdam sandstone, whilst the Portland rocks in like manner result from the "Upper" or St. Peter's sandstone. In Mr. Hall's Reports, I find no mention of the Portland rock.*

The formations immediately surrounding the locality in question are of Potsdam age, but, inasmuch as these rocks are much farther south than any of the similar isolated masses, we find now in the immediate vicinity not merely the sandstone, or lower representative of the Potsdam period, but also, and mainly, the Lower Magnesian limestone or upper representative of that period. We find too, within a very short distance, the St. Peter's or "Upper" sandstone, and the Blue and Buff limestones, all of the Trenton period. In this case, then, the occurrence is even more strikingly peculiar than in the Sauk county region. Here we find a very much smaller area covered by the metamorphic rocks; these rocks are much further from the main Azoic mass, and the series of surrounding and entirely unaltered and undisturbed strata is much fuller. The accompanying map, enlarged from Dr. Lapham's Geological Map of Wisconsin, serves

* I find by studying more carefully Mr. Hall's Report of Progress of the Geological Survey of Wisconsin, for 1861, that he gives more proof of the Huronian or Azoic age of Sauk quartzites than I supposed when I wrote the article alluded to above. He may have had more proof in reserve for the final report, which reached only one volume before the survey was stopped. In the plate of sections given in that volume, the Sauk quartzites are represented *as rising in a series of anticlinal folds, instead of having a uniform dip to the north.* This shows that the ideas then entertained with regard to these rocks must have been erroneous.

to show the association of the quartzite with the undisturbed Silurian rocks.

A, A, A. Southern limit of Azoic rocks. 1, 2, 3, 4, 5, Masses of quartzite scattered within the Lower Silurian areas. 4, Sauk county Quartzites. 5, Portland, Dodge county, Quartzites. 6, 7, 8, 9, 10, Granite masses within the Lower Silurian area (according to Lapham). B, Northern Michigan Peninsula. C, Lake Superior. D, Lake Michigan. E, Illinois. F, Iowa. G, Minnesota.

The quartzite mass here covers an area of not more than three miles in an east and west direction, and much less than that in a north and south direction. On approaching from the east the rocks appear in the form of a low ridge, whose height in no case exceeds 75 feet above the general level of the country. The approach is across a low marshy ground, and the ridge though not high is thus made to stand out somewhat conspicuously. This marshy ground runs along all the western side and at the northern end completely encircles one portion of the ridge, making a marsh island of it. The junction of two sluggish marsh streams is near by, and in times of high water this island in the marsh is actually surrounded by water and accessible only by boat. It goes by the name of "Rocky Island." The highest point of the ridge, as well as the most marked exposures of rock, is found at this place. The ridge is very narrow from east to west, and descends almost immediately on the eastern side to a shallow valley. The more

eastern exposures are on a corresponding low ridge farther to the east, and are of less extent.

The rock is almost entirely quartzite. In a few places I found outcrops of a metamorphic conglomerate like that observed in Sauk county, and in still fewer places very thin seams of a talco-siliceous schist are visible. I found none of the siliceous slate like that observed at the narrows of the Baraboo river. The quartzite is of a lightish grey color, very compact and uniform, showing neither the tendency to pass into a sandstone, nor the deep red color apparent in some parts of the Sauk quartzite. The laminated structure is visible in some places, but never with the distinctness of that apparent at Devil's Lake. The dip is very obscure. The different systems of vertical joints—there seem to be as many as three—and the bedding joints, are so confused that it becomes very difficult without long study to ascertain the dip accurately. It certainly is at a very high angle. Considering together the directions of the various joints, the laminated structure, and the mode of occurrence of the intercalated talcose material, the weight of testimony would seem to point to a uniform N.N.E. dip, at a very high angle. Along the lines of separation of some of the joints —probably not bedding joints—the quartzite shows smooth polished faces of considerable extent; this peculiarity was observed with the Sauk quartzite also. Glacial markings are quite apparent in many places along the top of the ridge. The markings bear N.N.E. and S.S.W. The peculiar rounded form of exposed surfaces along the top would seem to be partly due to glacial action.

I was not able to find the quartzite and associated unaltered rocks in direct contact, but by carefully following the ridge to the southward, in which direction it gradually becomes lower, I was able to trace the outcrop of the quartzite continuously to within a few rods of a deep cutting on the Milwaukee and St. Paul railroad. In the lower part of this cut I found the horizontal layers of thinly laminated siliceous limestone, which are characteristic of the gradation of the Potsdam sandstone into the Lower Magnesian limestone. The occurrence of Blue or Trenton limestone not more than a mile to the westward, as represented on Dr. Lapham's map, was verified.

It would seem that three different theories have been advanced with regard to the age of these rocks: 1st, that they are Azoic or "primary;" 2d, that they are altered from the Potsdam sandstone; 3d, that they are altered from the St. Peter's sandstone. I make the following arguments in favor of the first of these.

1st, *The exceedingly limited area of disturbance.* This argument is the same as that advanced in favor of the Azoic age of the Sauk quartzites. The idea of such thorough alteration and dis-

turbance over a small area, away altogether from any great system of metamorphism is inadmissible.

2d, *The occurrence close by of horizontal layers of Potsdam age.* These layers indicate the lower portion of the upper member of the Potsdam group. The quartzite, if altered from the "Lower" *sandstone*, must have been made, upheaved, and worn down *in the interval between the close of the sandstone epoch and the beginning of that of the limestone.* But these formations everywhere throughout the State graduate imperceptibly into one another; in other words, *there was no interval.* That the quartzite cannot have been altered from the St. Peter's sandstone, as stated by Percival, is also shown by these horizontal layers. A sandstone could hardly be changed to quartzite, whilst the beds immediately underlying it are left unaltered and undisturbed.

3d, *The thoroughness of the change in the rocks.* This is an additional proof that the metamorphism must have been a part of some great system of changes and foldings, and not the result of an action restricted entirely to an area of a few square miles.

4th, *The probable uniform dip to the N.N.E.* The indication of a *uniform dip* at a very high angle, together with the absence of any sign of an anticlinal, is direct proof that the quartzites are older than the undisturbed beds of the Potsdam period, which lie near by. The time that elapsed after the deposition of the Potsdam beds, must have been long enough to cover the time of upheaval and metamorphism, as well as the time requisite to erode all traces of an anticlinal.

I may say then confidently that these rocks are older than the Potsdam; that they received their present form before the laying down of the Lower Silurian strata; and that we find in them simply another outlying island in the Potsdam seas.

Relation to the main Azoic body, and to the other detached Azoic masses of the State. The accompanying outline map of Wisconsin serves to show these relations. A, A, A, is the southern line of the Azoic body; 1, 2, 3, 4, 5, the patches of quartzite, according to Lapham's map, lying within the Lower Silurian area; 6, 7, 8, 9, 10, are similarly isolated masses of granite or granitoid rocks. The Sauk quartzite ridges are marked 4; that of Portland 5. It will thus be seen that the last named is much the most distant from the Azoic body.

Can these quartzite areas be regarded as Huronian? The kinds of rocks (quartzites, conglomerates, siliceous slates), the distinct stratification, the no less distinct lamination, ripple markings, etc. (Devil's Lake), and the absence of granitoid rocks, would seem to show a close similarity between the rocks of these isolated areas and those in northern Wisconsin and northern Michigan now regarded as Huronian.

University of Wisconsin, Dec. 14, 1872.

Art. XXXII.—*On the Oregon Borate of Lime* (*Cryptomorphite?*); by A. W. Chase.

Curry County, Oregon, is the southernmost of the coast counties of that State, and lies directly north of latitude 42°, the boundary line of California. The entire county, with the exception of a narrow strip of arable land on the sea coast, and the alluvial bottoms of the Rogue and other rivers, is filled with ranges of rugged mountains, lateral spurs of the Siskyion, whose snow summits are everywhere visible. The only wheel-road in the county runs from the boundary to the Chetko river, a distance of eight miles; from thence a bridle trail leads to the settlements of Ellensburg, Port Orford, etc. Five miles north of the Chetko and directly on the sea coast is the locality of the borate deposit to be described. The country in the immediate vicinity resembles a succession of terraces, from one to two hundred feet above the sea level. From these terraces numerous rounded hills, some of them perfect cones, arise, generally reaching an altitude of two hundred feet above the flat. Back of these terraces lies a long range of mountains 2000 feet high. One peak of this range called Red Mountain, from the character of the rock exposed (a reddish sandstone), forms a perfect dome, and is at the head of the stream on which the borate was found, and five miles from the sea.

Through the terraces the brooks coming from this range have cut deep cañons, the rocks exposed in the beds being talcose slate and serpentine. Immediately in the vicinity of the borate deposit the hills slope downward so as to form three sides of a perfect crater, the bottom of which must be under water.

The coast is bordered with innumerable rocks of conglomerate and metamorphic sandstone, and the depth of water is very great within a few hundred feet of the shore line. The beach is strewn with masses of conglomerate rock composed of pebbles of agate, carnelian, jasper, and quartz, bound together by a cement of sandstone; through fissures and breaks in these rocks, veins of carbonate of lime of a milk-white color are found, many of them several inches in thickness. Two small streams cut their way down from the mountains and empty into the sea within the limits of the little bay, which is about three quarters of a mile in extent. On one of these streams a farmer located some ten or twelve years ago, and has occupied the place ever since, engaged in cattle raising. The locality was appropriately named the "Lone Ranch," his nearest neighbor being five miles distant. His attention was early called to an outcrop on the banks of the little stream, about 500 yards from the sea, and

20 feet above it, of a white substance which he called "chalk." When it was known that farmer Cresswell had chalk on his place, the coopers at the fisheries on the Rogue river and the carpenters in the little towns sent for some, and for years afterward it was used in cooperage and to chalk carpenters' lines. Masses of it exposed by winter floods were washed out to sea.

My attention was called to the deposit in 1872, and then chiefly from the fact that it proved an excellent polishing material for silver. On presentation of a specimen to the California Academy of Science by the President, Prof. Davidson, it was pronounced borate of lime. On a subsequent examination by the San Francisco Microscopical Society, Mr. H. G. Hanks, chemist, exhibited the rhombic character of the crystals, and also the fact that it contained no diatoms, and pronounced it cryptomorphite.

The substance having commercial value, it was mined during the past summer, and the following information concerning the character of the deposit obtained. In cutting away the bank above the spot where the first outcrop appeared, several layers or strata were met with, of varying thickness. The first in order was a soft green clay or decomposed talc, with streaks and globules of a white, waxy substance, itself another form of steatite. The second, a layer of black slate or rock broken into a thousand fragments and resembling coal. Then a layer of slate, seamed with white veins and masses of decomposed talc. These layers did not contain any traces of boric acid. Then came a layer of hard, white borate, filling the seams and cavities of the slate, and pressing down on the layer beneath, which was a tough blue steatite with green and white veins and of the consistency of clay. Wherever a hollow had formed in the blue steatite, the hard borate pressed down into it and formed a hemisphere, the upper parts being mixed with slate, the lower pure. In the blue steatite and a few inches below the slates, the main vein or flow was found. Here the borate was in the form of boulders or rounded masses, completely imbedded in the steatite, and in shape not unlike a pumpkin or squash, the sides being corrugated and having little depressions in the top surface. These boulders formed a continuous line touching each other, and were of uniform size in the main flow, weighing about two hundred pounds each, although some were much larger, one weighing four hundred and fifty. Branching off from the main deposit were side flows, where the boulders ran from twenty pounds down to small pellets the size of a pea, and even smaller.

These masses were all perfectly pure and each complete in itself. When broken apart the fracture exhibits no luster.

The color is milk-white; feel greasy and unctuous. Before the blowpipe the substance exhibits the usual green flame.

The following is the analysis of the two kinds, the hard borate found in veins and the boulders or masses:

Boulders.

Water	22·75
Lime	29·96
Alkalies	·25
Chlorides	*traces*
Boracic acid	47·04=100·00

Hard Borate.

Water	25·00
Lime	29·80
Alkalies	*traces*
Boracic acid	45·20=100·00

The above analysis was made on average samples from large quantities for commercial purposes, and owing to the presence of a large percentage of water the average of acid was reduced. A small portion, thoroughly dried, previously tested, yielded as high as 55 per cent. The quantitative analysis was made in the office of Gen. Hewston, San Francisco Assay and Refining Works, by Mr. Thomas Price, chemist.

It will be seen from the above analysis that soda is entirely absent, the composition being purely lime, water, and boric acid, forming thus a hydrous borate of lime. The appearance of the material and the shape in which it is found does not correspond with any of the described varieties in Dana's "Mineralogy," and it might be called a new variety. The adjacent steatite and earths, as well as the slates, do not show the slightest trace of boric acid. In working, empty cells were frequently struck, of the exact shape and size of boulders lying near them. These cells had an inside incrustation of a semi-transparent nature, covered with little protuberances or pimples. This substance also gave a green flame with sulphuric acid and alcohol.

In forming a theory as to the origin of this deposit, it is impossible to resist the conclusion that it came from a spring of boric acid in the crater of what was probably a mud volcano.

The different layers of steatite and clays being first ejected, the acid, possibly in the form of vapor from a hot spring, must have passed through a layer of carbonate of lime; holding this in suspension the vapor penetrated the possibly liquid mud, and formed cells in it somewhat similar to air bubbles. As the mud cooled it pressed on these cells from all sides—the cooling of the vapor or water also allowed it to deposit; the matter in suspension which pressed by the mud assumed the crowded and corrugated shape that it is found in at present.

The vapors that escaped from the steatite were caught by the slate above, and formed as vein matter in the fissures.

Further development of this probably unique deposit may lead to a change in this theory, but at present it seems the only hypothesis to account for the presence of this pure borate in a substance which does not itself possess any trace of either the acid or lime.

Art. XXXIII.—*Explorations West of the 100th Meridian.*

(Communicated by Dr. H. C. Yarrow.)

The third field season of explorations and surveys under Lieut. Geo. M. Wheeler, Corps of Engineers, was brought to a close about the beginning of December last, and the scientific corps is now busily engaged in office-work in Washington, elaborating the data obtained. The areas embraced in the season's work covered western and southern Utah, eastern Nevada and northern Arizona, as far as the Grand Cañon of the Colorado, and taken in connection with the labors of 1869 and 1871, amount in extent to the territory of the New England and Middle States combined. These three surveys, in 1869, '70 and '72, have been made to supplement and perfect each other in such a way that the Lieutenant's mapped field now extends from central California over a large part of Nevada, as far east as central Utah, and south over the larger part of northern, western and central Arizona.

The initial aim in the work of the Survey is the accurate mapping of the countries traversed, and the correction of the engineers' map of the United States west of the 100th meridian. For this purpose there is a corps of trained topographers connected with the expedition, whose operations during the past season were much facilitated, and the accuracy of their results much enhanced, by means of a comprehensive series of astronomical stations, at various points, either nearly or remotely connected with the field of survey, extending from Cheyenne, Wyoming, on the line of the Union Pacific, to Beaver, in lower Utah. The value of these astronomical stations, and the tables of observations taken, can hardly be overestimated, when considered with reference to the perfecting of surveys in a country where so many physical obstacles stand in the way of accurate geodetic work. In addition to the astronomical work, hourly meteorological observations were made, at different points in the region surveyed, and the accumulation of data from this source alone is great. The various departments of geology, mineralogy, meteorology, natural history, and ethnology were filled and administered with vigor, and a valuable gallery of

photographic views secured from the Grand Cañon of the Colorado, as well as from Utah, by Mr. Wm. Bell, a skilled photographer of Philadelphia; characteristic sets of views selected from these are now preparing, under orders from the War Department, for exhibition at the Vienna Exposition during the coming summer.

In the line of natural history, Dr. H. C. Yarrow and his assistant, Mr. H. W. Henshaw, made valuable collections from the flora and fauna of the territory entered, including not less than five hundred bird-skins from Utah, which have been received in Washington in excellent preservation. The geologists of the expedition, Messrs. G. K. Gilbert and E. E. Howell, besides the strictly special work of their profession, effected a labor of economic value, by entering many mining camps in Utah and Nevada, and examining thoroughly the developments and possibilities of the various districts; aided in this by the surveyors and astronomers of the corps, who set up, in several mining districts, astronomical monuments bearing the latitude and longitude of the places, for the convenience of local surveys. The topographers of last season were Messrs. Louis Nell, J. Weyss, H. Crueger, and G. Thompson, and the astronomers, Messrs. J. H. Clark, E. P. Austin and W. W. Maryatt. The ethnologist of the expedition, Mr. M. S. Severance, made extensive researches in the ancient mounds, and recent graves, of the Indian country, and secured from these sources a dozen or more crania and skeletons, besides numerous relics of various age and value, and a considerable addition to the Ute and other dialects. Lieuts. R S. Hoxie and W. L. Marshall, of the engineers, aided Lieut. Wheeler in the executive administration of the expedition, besides giving somewhat attention to astronomical and topographical subjects. Lieuts. W. A. Dinwiddie and W. Mott were in command of the cavalry and infantry escort, respectively.

Much of Lieutenant Wheeler's attention was devoted to subjects collaterally associated with the main object of the survey, relating to the internal economy of the vast areas traversed, and the elucidation of industrial questions of vital interest to settlers and miners; among these were the subjects of artesian wells and schemes of irrigation to reclaim the wide-spread barren wastes of that region, the limiting of the areas within which mineral croppings may reasonably be expected, the discovery of new routes of travel and transportation, and favorable positions for the establishment of military posts, the collection of data bearing on agricultural questions and the limits of population, and other investigations of equal importance in the development of a new country and the improvement of regions sparsely settled.

ART. XXXIV.—*On Footprints in the Carboniferous rocks of Western Pennsylvania;* by W. D. MOORE.

IN 1846, Dr. Isaac Lea discovered, in the coal strata near Pottsville, footprints similar to those discovered by Dr. King in 1844. Another example of similar footprints has been discovered in a quarry, on the farm of Commodore Rogers, three miles north of the city of Pittsburgh, Pennsylvania. The tracks found by Dr. King occurred about 100 to 120 feet below the Pittsburgh coal seam, near a little town called Pleasant Unity, not far from the base of Chestnut ridge. In precisely the same situation geologically were the tracks found of which I send you a cast, and rather imperfect drawing. The Pittsburgh coal seam is worked on the hill side, above the quarry from which these tracks were obtained, by actual measurement 110 feet.

As in the tracks described by Dr. King, one of the toes stands out like an opposable thumb, giving the appearance of a hand to the track, and the number of toes is greater in the hind than the fore foot. The front track shows but three toes, but the abnormal thickness of the third toe shows to me conclusively that there were two, which have been, through a filling up with the soft mud, warped together; and the same has very nearly happened with the third and fourth toes of the hind foot. I believe also that a depression to the right of the heel of the front track, and to the left of the heel of the hind track, indicates the place of the thumb-like toe, which has been in both cases washed away; the very noticeable hollow running round both feet indicates the channeling out and washing away here suggested. If I am right in this supposition, then the tracks must have been originally at least a third larger. In giving the following description, however, I state the characters just as they are on the slab, referring the tracks provisionally to the genus *Cheirotherium.*

Cheirotherium Reiteri: Toes of hind foot four; directed to the left; left three of nearly equal length, 1¼ inches; the fourth much smaller and shorter, ¾ inch; heel 1 inch long; 1½ inch wide; length of foot 2¼ inches to 3 inches; length of step, 11 inches. Toes of the front foot three, directed to the right, of nearly equal length, thicker and shorter than those of the hind foot; heel apparently longer and wider.

The species is dedicated to Dr. Wm. C. Reiter, of Pittsburgh, an accomplished naturalist and an intimate friend and fellow laborer, in scientific pursuits, of Dr. King, the first discoverer of reptilian tracks in the Coal measures of Pennsylvania. The specimen is in the collection of the Western University of

Pennsylvania, and a second cast is in possession of Dr. W. C. Reiter, of Pittsburgh, Pa.

Before closing, I may remark that the sandstone, on which these tracks are found, like that, on which Dr. King's were found, is covered with mud-cracks, and numberless long trails, as of animals passing over the surface, but to what class referable I cannot tell. It is, moreover, covered with the most beautiful ripple marks; in one place in the quarry, a space of the stone about thirty yards long and twenty wide is exposed to view, and could easily at a little distance be mistaken for a shore just lapped by the retiring waves. In one locality, at the same geological horizon, Westmoreland county, Pa., some years since, I found an extensive and remarkable deposit of fossils, indicative of the conditions supposed to exist where these and similar tracks are found. In the thin black shales of that locality were confusedly mingled the characteristic plants of the coal and marine shells, a singular new species, described by my friend Leo Lesquereux as "*Crematopteris Pennsylvanica*"* and a well marked wing of an insect closely allied to that since found by him in the low coal of Arkansas, and described as "*Blattina venusta.*"† Some years subsequently at nearly the same geological horizon, in Washington county, Pa., I found a mass of fossil remains wholly unknown to me, but which I supposed to be fragments of a reptilian skeleton. They were given by me to Prof. Leo Lesquereux, and by him forwarded to Prof. Agassiz. I have not learned the result of Prof. Agassiz's examination.

ART. XXXV.—*Additional Observations on the Dinocerata;* by O. C. MARSH.

IN the article on Gigantic Fossil Mammals in the February number of this Journal (p. 117), I called attention to numerous errors in Prof. Cope's recent publications on the same subject. Some of these mistakes were made by Prof. Cope in describing his own specimens; some by misunderstanding the characters of allied *Dinocerata;* and not a few in giving dates and references which were not correct. These specific points against his work, some twenty in number, Prof. Cope has not answered. He has, however, endeavored to break the force of my criticism by a general denial, which evades the main issue between us, as I have recently shown in the American Naturalist for March (p. 146). He says, in substance, that one species of *Eobasileus* is different

* Geological Report of Pennsylvania, vol. ii, p. 868.

† Geological Reconnaissance of Arkansas, p. 314.

from one of my species; but this would not materially diminish the list of his errors on this subject. Prof. Cope distinctly included in his group of supposed Proboscidians the genera *Dinoceras* and *Uintatherium*, thus mistaking, as I have shown, both their characters and affinities, as well as those of his own specimens. Prof. Cope states further, that I have not seen his *Eobasileus*. I have already expressed my belief that what he has called *Eobasileus* was merely my genus *Tinoceras*, and, as shown below, this is now established beyond a doubt. Prof. Cope asserts, likewise, that the descriptions he has given are correct; but this is impossible, since he has made most contradictory statements about the same characters of the same specimen. Prof. Cope has said, e. g., that *Eobasileus* had upper incisors, but no canines; next, that it had canines, but no incisors; and, finally, that it had one incisor and one canine. He has stated, also, that the anterior horn-cores were on the frontal bones; that they were on the nasals; and even that they were in part on the maxillaries. He tells us, moreover, that the nasal bones were greatly elongated; and again, that they were extremely short; that the horn-cores of *Eobasileus* were six inches in length; and, next, that they were a foot long; that the spine of the tibia was obtuse; and again, that it was wanting; and, strangest of all, that the premaxillary was both edentulous, and a trenchant tusk!

The March number of the Naturalist, in which I have pointed out Prof. Cope's numerous errors on this subject, contains another article by him on the *Dinocerata*. This paper, likewise, is not free from serious mistakes and inaccuracies, which show that Prof. Cope still misinterprets some of the most important characters of his own specimens. The paper purports to have been read at the Dubuque meeting of the American Association of Science, but it evidently includes the results of Prof. Cope's later investigations, as well as corrections suggested by my recent criticisms. This is equally the case with the appended paper, which was first issued separately, and has just been re-published in an emended form.*

Since the March Naturalist was published, I have had an opportunity, through the kindness of Prof. Agassiz, of examining a series of photographs of the skull described as *Eobasileus cornutus*. These views fully confirm my previous belief in regard to this specimen, viz: that it belongs to the genus *Tinoceras*, and hence to the *Dinocerata*, the species being apparently *T. grandis* Marsh. The photographs show, moreover, that Prof. Cope has from the first mistaken many characters of this genus, and hence his erroneous conclusions in regard to the group to which it belongs.

Some of Prof. Cope's errors in dates and references which I have pointed out, he has corrected in his later papers, and these need not be repeated. In his last note on *Eobasileus*,† however, he has re-asserted that his descriptions are correct, and hence this point deserves consideration, especially as we now have the means of

* Proceedings Philadelphia Academy, p. 11, 1873.

† American Naturalist, vii, p. 180, March, 1873.

testing the accuracy of these descriptions. The photographs of Prof. Cope's *Eobasileus*, examined in connection with many similar remains in the Yale Museum, make it evident that the various objections I have raised against his work are, almost without exception, well founded. His more recent errors, as well as those remaining in his dates and references, should be placed in the same list, in judging of the value of his papers on the *Dinocerata*. These papers still need correction on the following points:—

1st. The name *Eobasileus* Cope is a synonym of *Tinoceras* Marsh, which antedates it (p. 122), and the name of the family, *Tinoceratidæ*, likewise has priority over *Eobasiliidæ*. 2d. The name *Loxolophodon* Cope should not be applied to this genus, as there is no satisfactory evidence that the single premolar tooth to which it was first given is generically identical, and the probabilities are against it. 3d. The species *Eobasileus cornutus* Cope appears to be the same as *Tinoceras grandis* Marsh, which was first described (Sept. 21, 1872). The species *E. furcatus* Cope, founded on portions of supposed nasal bones (which Prof. Cope has since called frontal bones), has at present no authority, the specimens described being evidently the posterior horn-cores of other known species. Judging from the descriptions, the name *E. pressicornis* Cope has apparently no better foundation. 4th. The genus *Dinoceras* Marsh is distinct from *Uintatherium* Leidy, although perhaps nearly related. 5th. The mammals of the above genera, and probably those of *Megacerops* Leidy, cannot be placed in the order *Proboscidea*, but constitute a distinct group, *Dinocerata*, which approaches the perissodactyls rather than the elephants. 6th. The presence of a proboscis does not directly result from the osteological characters of this group, but is quite inconsistent with them, and the evidence is decidedly against it. 7th. The skull in the *Dinocerata* has no distinctive proboscidian features, and the subordinate similarity in the limb-bones I pointed out before Prof. Cope wrote anything on the subject. 8th. The presence of canine teeth and horns was not alone stated by me to be characteristic of a new order, but other important characters were given (p. 121). 9th. The *Dinocerata* have no upper incisors, and the teeth called incisors by Prof. Cope are canines. 10th. These canines do not correspond to the tusks of Elephants, and the latter are not enclosed between the premaxillary and maxillary, but are inserted in the former bone. 11th. The nasal bones in the *Dinocerata* are much elongated, and their free extremities are not extremely short, or deeply excavated. 12. The frontal bones do not extend in front of the premaxillaries; their extremities do not form bony projections like shovels; and they do not support horns or processes at both extremities. 13th. The anterior horn-cores are on the nasal bones, and not on the frontals; and they are not composed externally of the maxillaries. 14th. The middle pair of horn-cores, likewise, are not on the frontals, but on the maxillaries, their inner inferior margin alone being formed of the nasals. 15th. The orbits were not below these horns, but behind them,

especially when the head was in its natural, declined position. 16th. The malar does not form the middle of the zygomatic arch, merely, as in the Elephant, but extends in front of the orbit, as in the Tapir. 17th. The temporal fossæ are not small posteriorly. 18th. The occiput is not vertical, but oblique. 19th. The tarsus and foot are not proboscidian in character, strictly, but show strong perissodactyl features, e. g., in the absence of a hallux, and in the articulation of the astragalus with both the navicular and cuboid bones. 20th. The genus *Dinoceras* was not originally referred to the Perissodactyls, but to a new order. 21st. The name *Tinoceras* was not first proposed August 24, 1872, but August 19, 1872, and on that day I mailed Prof. Cope the pamphlet containing it. 22d. The characters given in describing *Tinoceras anceps* Marsh* pointed directly toward the Proboscidians, and this fact was distinctly stated. 23d. Many of the erroneous dates and references which I have pointed out (pp. 118, 122, and 135) in Prof. Cope's recent publications remain uncorrected.

The species of *Dinocerata* at present known with certainty are the following:—*Tinoceras anceps* Marsh, *Tinoceras grandis* Marsh, *Uintatherium robustum* Leidy, *Dinoceras mirabilis* Marsh, *Dinoceras lacustris* Marsh. To these should probably be added *Megacerops Coloradensis* Leidy, and also *Tinoceras cornutus* = *Eobasileus cornutus* Cope, if this species should eventually prove distinct.

Yale College, New Haven, March 10, 1873.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Considerations on some Points of the Theoretic Teaching of Chemistry.*—The Faraday lecture before the Chemical Society of London, was delivered by Professor Cannizzaro, now of Rome, upon the above subject. Standing among the first of living chemists, as the distinguished author does, his views upon the value of chemical theories in teaching have an importance amply justifying some notice of them here. Accepting fully the theory of atoms and molecules, and believing that "this theory affords the clearest, shortest, most exact and most accessible summary of all that relates to the origin, meaning, value and use of empirical formulæ and of equations," he naturally concludes that "it ought to be introduced into the teaching of chemistry at an early stage." "I do not hesitate to assert," he continues, "that the theory of atoms and molecules ought to play in the teaching of chemistry, a part analogous to that of the theory of vibrations in the teaching of optics." Affirming that "the solid base, the corner stone of the modern theory of molecules and atoms, is the theory of Avogadro, Ampère, Krönig and Clausius on the constitution of perfect gases," he would "found on this theory the demonstration

* This Journal, vol. ii, p. 35, 1871.

of the limits of divisibility of elementary bodies; that is to say, the existence of elementary atoms." With his own classes, Cannizzaro begins by establishing the invariability of mass in chemical changes, pointing out the fact that "the only constant property of matter is its ponderability." He then passes to the Daltonian theory, establishes, by means of Gay Lussac's law of combining volumes, the correctness of the atomic weights, and then easily demonstrates the molecular condition of simple matter; thus placing the fundamental notions of atom and molecule upon a solid basis, freed from everything not necessarily connected with them. Then only it is "that we are in a position to attack the difficulties encountered in the applications of these notions to particular cases." The assistance of specific heat, of isomorphism and of chemical analogy in fixing the size of molecules, and the true meaning and value of the theory of atomicity may then be introduced, the student being taught to recognize the dynamic as well as the ponderable phenomena of chemical change.—*J. Chem. Soc.*, II, x, 941, Nov., 1872. G. F. B.

2. *On the Relation between Vibration and Detonation.*—CHAMPION and PELLET have made some experiments which fully confirm Abel's theory that detonants explode by a peculiar mechanical vibratory stimulus. They found, for example, that nitrogen iodide could be exploded at one end of a glass tube 22 feet long by means of a little of the same substance detonated at the other; and this when the tube was in two pieces joined in the center by a paper band. On fastening a bit of nitrogen iodide by means of gold-beater's skin, to the strings of a bass-viol, it was observed that when placed on the two lower strings it did not explode when these were vibrated; while that on the highest string exploded instantly. This string vibrated 30 times per second. Similar results were obtained with Chinese gongs. To show that hea had nothing to do with the result, the quantity of nitro-glycerin, of mercuric fulminate, and of gunpowder necessary, when placed in one focus of a parabolic mirror, to explode nitrogen iodide at the other, was measured; and it was found that an amount of gunpowder was needed which would evolve ten times as much heat as the necessary amount of nitro-glycerin. Moreover, blackening the mirrors prevented the explosion by gunpowder, but left that by nitro-glycerin unaffected. The authors subsequently reversed the experiments and studied the vibrations produced by the detonation of the above compounds. By means of a series of sensitive flames, arranged according to the complete scale of *g* major, and before which at five meters distance, 0·03 grm. nitrogen iodide or mercuric fulminate was exploded, they showed (1) that the vibrations caused by the two explosions are very different, the former having no effect, while the latter excited the flames *a, c, e, f, g;* and (2) that the vibrations produced belong only to certain notes of the scale. Nitro-glycerin, nitro-glycol, nitro-erythrite and nitro-dulcite, gave no results with this apparatus.—*C. R.*, lxxv, 110 and 712, 1872. G. F. B.

3. *On Cœrulignone, a coloring matter from Pyroligneous acid.*—When the crude calcium acetate obtained in the distillation of wood is distilled with the necessary quantity of hydrochloric acid, and the distillate is purified by adding some potassium dichromate, there forms a blue film upon the surface of the acetic acid, which finally sinks and forms a violet sediment. LIEBERMANN has examined this substance. After washing, he dissolved it in cold phenol and precipitated it by alcohol in the form of dark steel blue needles, which had the composition $C_{15}H_{14}O_6$ or $C_{30}H_{30}O_{12}$, and to which the author gives the name *cœrulignone.* It is almost insoluble in ordinary solvents, concentrated sulphuric acid dissolving it with a blue color, potassium hydrate to a green liquid, while nitric acid oxidizes it to oxalic acid. It is decomposed by heat and does not dye either with or without a mordant. Observing its formation by the addition of potassium dichromate to several samples of crude acetic acid, Liebermann inferred the presence in the acid of some body which yielded it on oxidation. Hence he reduced cœrulignone by tin and hydrochloric acid, and obtained a colorless body in crystalline needles, $C_{15}H_{16}O_6$, soluble in alcohol, melting at 190°, capable of being distilled, and changing to cœrulignone by oxidation. He calls it *hydro-cœrulignone,* and considers it a phenol, of which cœrulignone is its quinone or its quinhydrone.—*Ber. Berl. Chem. Ges.*, v, 746, Oct., 1872. G. F. B.

4. *On the Synthesis of Anthracene.*—Limpricht produced anthracene by heating benzyl chloride with water. Beside anthracene $C_{14}H_{10}$, there is also produced a liquid hydrocarbon $C_{14}H_{14}$. VAN DORP, having observed in the synthesis of dimethylanthracene, the production of a homologue of this body, which, passed through a red hot tube, was converted into dimethylanthracene with evolution of hydrogen, was led to test the same question in the case of the hydrocarbon $C_{14}H_{14}$. By Limpricht's method he prepared this substance, boiling at 280°, and found that by passing it through a red hot tube filled with fragments of pumice, hydrogen was evolved and anthracene abundantly formed. As this liquid hydrocarbon, when oxidized with chromic acid, yielded benzoylbenzoic acid, it must consist of benzyltoluol, $C_6H_5CH_2{-}{-}{-}C_6H_4CH_3$. To prove it, benzyltoluol, boiling constantly at 275° to 280°, was prepared and its vapor conducted through tubes containing pumice fragments and heated to low redness. Pure hydrogen was evolved and there condensed in the tube a solid hydrocarbon mixed with the excess of liquid used. On expression and repeated crystallization from glacial acetic acid, slightly yellow crystalline plates, fusing at 213° and having the composition $C_{14}H_{10}$ were obtained. Conversion into picrate, and the production of anthraquinone and alizarin proved it to be anthracene. The yield was but 10 per cent. Yet by improved methods it may be increased probably to the theoretical amount. The author believes the process to be of technical value. —*Ber. Berl. Chem. Ges.*, v, 1070, Jan., 1873. G. F. B.

5. *New method for preparing Alizarin.*—GIRARD proposes the following method for the preparation of alizarin from crude anthracene, boiling between 300° and 335°: Treat the mass first with potassium chlorate and hydrochloric acid, in order to obtain tetrachlorinated products. Oxidize these, either by nitric acid or by a metallic oxide (as lead peroxide), with sulphuric or acetic acids; obtaining thus a mixture of dichloranthraquinone and chloroxyanthranil chloride. In presence of a metallic oxide (zinc, copper or lead oxide) treat these bodies with an alcoholic solution of sodium acetate. The last atom of chlorine is thus removed and alizarin is the result. This may then be purified.—*Bull. Soc. Ind. Mulhouse*, xlii, 54; *J. Chem. Soc.*, II, x, 1138, Dec., 1872.

G. F. B.

6. *On the Hydrates of Monobasic fatty acids.*—GRIMAUX suggests the existence of bodies analogous to the glycerins, but in which the hydroxyls are united to the same carbon atom. These bodies he calls *carberins*. They are produced by hydrating the monobasic fatty acids. Thus, fomic acid $CH\begin{cases}O\\OH\end{cases}$ plus H_2O gives $CH\begin{cases}OH\\OH\\OH\end{cases}$ formyl-carberin; acetic acid $CH_3.C\begin{cases}O\\OH,\end{cases}$ gives $CH_3.C\begin{cases}OH\\OH\\OH,\end{cases}$ acetyl-carberin. These hydrates are known and have been described. Moreover, chloral hydrate is a chlorinated glycol, having two hydroxyls united to the same C atom; $CCl_3.CH\begin{cases}OH.\\OH\end{cases}$ The carberin ethers, as $CH\begin{cases}(CHO_2)\\OH\\OH\end{cases}$ or $CH_3.C\begin{cases}(C_2H_3O_2)\\OH\\OH,\end{cases}$ are diformic or diacetic acids; and $CH_3.C\begin{cases}(C_4H_7O_2)\\OH\\OH\end{cases}$ is aceto-butyric acid. The chlorhydrin $CH\begin{cases}Cl\\Cl\\Cl\end{cases}$ is chloroform; $CH\begin{cases}OC_2H_5\\OC_2H_5\\OC_2H_5\end{cases}$ is known as ethyl subformate.—*Bull. Soc. Ch.*, II, xviii, 535, Dec., 1872.

G. F. B.

7. *On a Boiler Incrustation from New Jersey;* by GEORGE A. KOENIG, Ph.D.—Some time ago Mr. Joseph Harrison, Jr., presented to the Academy a specimen of boiler incrustation from Orange Co., N. J. The physical properties of this incrustation were remarkable enough to suggest a chemical examination. It was about half an inch thick, presented a smooth surface, was hard and coherent, of a brownish flesh-color, and showed on the fracture a distinct prismatic structure, the prisms standing vertically on the surface. It looked very much like the so-called "Sprudelstein" fron Karlsbad in Bohemia, which is aragonite.

The analysis gave the following results:—Sulphuric acid (SO_3) 57·58, calcic oxide (CaO) 40·40, ferric oxide (Fe_2O_3) 0·54, silicic acid (SiO_2) 0·05, organic substance and water 1·00=99·57.

57·58 parts of sulphuric acid require, by theory, 40·306 parts of calcic oxide to form calcic sulphate, which latter number corresponds perfectly with the one found; we can say, hence, that the incrustation is composed of: Calcic sulphate 97·89, ferric hydrate 0·72, silica 0·05, organic matter 0·82.

To my knowledge there has not been described, so far, a boiler incrustation which is so very near chemically pure calcic sulphate, and none in which this is so perfectly anhydrous. We know that calcic sulphate occurs in nature in two forms. In one it is combined with two equivalents of water, viz:—Calcic sulphate 79·07, water 20·93, crystallizing in oblique rhombic prisms, and is called gypsum. In the other it is without water, crystallizes in orthorhombic prisms, and is named anhydrite.

We know, further, that gypsum begins to lose water not much above the boiling point of water, and can be rendered anhydrous by prolonged heating at about 200° Centigrade. Still it seemed of interest to ascertain what changes would take place in a saturated solution of gypsum when evaporated under the atmospheric pressure at the boiling point, and also under a higher pressure.

A saturated solution of gypsum was kept at the boiling point until an ample amount of precipitate had formed. This precipitate consisted of minute scales with a marked silky luster. Under a magnifying power of 60 diameters the scales proved to possess the characteristic tabular forms of *gypsum* with the oblique base. They were perfectly transparent, and many were twins, those swallow-tail-shaped forms so well known. Upon ignition 20·7 per cent of water was found instead of 20·93, as required by the formula.

A saturated solution of gypsum was now sealed up in a glass tube, and kept in an oil bath for fourteen hours at a temperature of 148° Centigrade. This temperature is equal to a pressure of 4·4 atmospheres, or 66 pounds to the square inch. A slight granular precipitate was found on the glass after removing the tube from the bath and drawing off the mother liquor. Under a magnifying power of 120 diameters the apparent granules dissolved into stellate groups of needle-shaped crystals intermixed with single needles of a larger size. Most of the crystals had the oblique rhombic basal termination of gypsum; but some showed an orthorhombic basis. All the crystals had became opaque, apparently by innumerable fissures, as a network could be discerned in many individuals. The presence of prismatic protuberances on some of the crystals standing at right angles to the principal axis of the main crystal seemed very curious.

The precipitate was now removed from the tube and carefully washed, then dried over sulphuric acid. After ignition a loss was produced of 3·1 per cent. Taking into consideration that not all of the mother liquor was washed out and crystallized as gypsum, this result may be looked upon as confirmatory that the whole of

the precipitate is *anhydrite.* Professor Genth is of opinion that the opaque stellate crystals are pseudomorphs of anhydrite after gypsum, and I see at present no reason to the contrary.

In nature we find the anhydrite associated with rock salt. Supposing that the deposition of the chlorides of sodium and potassium took place under a moderately high column of saturated water, the pressure exercised by this column would give a satisfactory explanation for the fact that calcic sulphate crystallized as anhydrite. The presence of gypsum in the same deposits would suggest a subsequent metamorphosis of the anhydrite into gypsum by taking up water.—*Proc. Acad. Nat. Sci. Philad.*, Jan. 4.

8. *Effect of Light on Selenium during the passage of an electric current.**—Being desirous of obtaining a more suitable high resistance for use at the Shore Station in connection with my system of testing and signalling during the submersion of long submarine cables, I was induced to experiment with bars of selenium, a known metal of very high resistance. I obtained several bars varying in length from 5 to 10 centimeters, and of a diameter from 1 to 1½ millimeters. Each bar was hermetically sealed in a glass tube, and a platinum wire projected from each end for the purpose of connection.

The early experiments did not place the selenium in a very favorable light for the purpose required; for, although the resistance was all that could be desired—some of the bars giving 1,400 megs. absolute—yet there was a great discrepancy in the tests, and seldom did different operators obtain the same results. While investigating the cause of so great differences in the resistance of the bars, it was found that the resistance altered materially according to the intensity of light to which it was subjected. When the bars were fixed in a box with a sliding cover, so as to exclude all light, their resistance was at its highest, and remained very constant, fulfilling all the conditions necessary to my requirements; but immediately the cover of the box was removed, the conductivity increased from 15 to 100 per cent, according to the intensity of the light falling on the bar. Merely intercepting the light by passing the hand before an ordinary gas-burner placed several feet from the bar increased the resistance from 15 to 20 per cent. If the light be intercepted by rock salt or by glass of various colors, the resistance varies according to the amount of light passing through the glass.

To ensure that temperature was in no way affecting the experiments, one of the bars was placed in a trough of water so that there was about an inch of water for the light to pass through, but the results were the same; and when a strong light from the ignition of a narrow band of magnesium was held about nine inches above the water the resistance immediately fell more than two-thirds, returning to its normal condition immediately the light was extinguished.—*Nature*, Feb. 20.

* Communicated to the Society of Telegraph Engineers, February 12, by Mr Latimer Clark, from Mr. Willoughby Smith, Electrician to the Telegraph Construction Company.

II. Geology and Natural History.

1. *Note on the History of certain recent views in Dynamical Geology;* by Robert Mallet, F.R.S. (Letter to the Editors, dated Feb. 27, 1873.)—In reference to the notices, which are found in the February number of the American Journal of Science, of my views as to the nature and origin of volcanic energy and heat, and to a note at p. 156, by Professor Jos. LeConte, will you allow me to state that no question of priority can arise, as it seems to me, between that gentlemen and myself, as evolving from his very able paper in your Journal of November, 1872.

Neither Professor LeConte nor myself have any claim to the general idea of the elevation of mountain chains, etc., by tangential or lateral pressure. That belongs to Constant Prevost, who distinctly enunciated the doctrine and many of its consequences nearly forty years ago, though, like many other great and pregnant truths, this was for a long time completely and is even yet much neglected.

My own claims to originality comprised in my paper, read in abstract only to the Royal Society of London, and I regret to say not even yet published in full by that body, and of which I have given some account in my introduction to the translation of Prof. Palmieri's Eruption of Vesuvius of 1872, may be principally as follows: 1st, That volcanic heat and energy have their origin in the *transformation* of work into heat, the work arising from the movements (chiefly of descent) of the crust of a terraqueous cooling planet.

2d. The *colligating* the phenomena: 1st, of deformation of this spheroid, producing ocean and land; 2d, of elevation of mountain, and generally of all elevation and *depression* of hypogeal origin, including fissures and faults, etc.; 3, of vulcanicity, including volcanoes and earthquakes, etc., as all successive results of the same simple cosmical mechanism, the energy of which has decayed and is decaying with time, since the period when the train commenced, viz., when our globe became a molten spheroid thinly crusting over.

Those views have for many years been gradually maturing in my thoughts. I have from time to time communicated them more or less fully to several scientific friends, especially to my friend Professor Houghton, of the University of Dublin. I also took date as to them by letter addressed to Professor Stokes, Secretary of the Royal Society of London, dated January, 1870, a copy of which is before me. So far therefore, as there may be anything in common beween the thought of the valuable and suggestive paper of Prof. LeConte and my own above referred to, I endorse his statement that they are independent respectively in date as in conception.

I have looked into Mr. Vose's work on Orographic Geology, published 1866, to which Prof. LeConte's note (p. 156) directs attention in these words:

"In justice to Vose, I ought to draw attention to the fact, that Mallet's very excellent idea that *heat is produced by pressure*, is brought out distinctly in his [Vose's] volume. He, however, did not extend the idea to vulcanism but only to metamorphism."

Vose's expressions are everywhere very vague; the clearest that I can find occur at pp. 109–110 and 132, in which it is quite true that he connects in some unexplained way, as contemporaneous action, heat-pressure and chemical forces as conjointly in some way giving rise to metamorphism; but I am unable to discern any evidence that he entertained the slightest notion of the *transformation of work into heat*, as producing metamorphic or any other geological effects. On the contrary, Prof. LeConte's own words, *heat produced by pressure*, may describe Vose's notions, so far as I can gather them; and if I have failed to do so or have misstated them I shall be happy to be corrected; certainly they do not properly describe mine. Heat *cannot* be produced by pressure; pressure and motion, i. e., work, can be *transformed into heat*, but of such a transformation I fail to find that Vose has given any hint.

2. *The Classification of the Pleistocene Strata of Britain and the Continent by means of the Mammalia;* by W. Boyd Dawkins, Esq., M.A., F.R.S., F.G.S.—The Pleistocene deposits may be divided into three groups:—1st, that in which the Pleistocene immigrants lived, with some of the southern and Pliocene animals in Britain, France, and Germany, and in which no arctic mammalia had arrived; 2d, that in which the characteristic Pliocene Cervidæ had disappeared, and the *Elephas meridionalis* and *Rhinoceros Etruscus* had been driven south; 3d, that in which the true arctic mammalia were the chief inhabitants.

The third or late Pleistocene division must be far older than any Prehistoric deposits, as the latter often rest on the former, and are composed of different materials; but the difference offered by the fauna is the most striking. In the Pleistocene river-deposits twenty-eight species have been found, the remains of man being associated with the lion, hippopotamus, mammoth, wolf, and reindeer. On examining the fauna from the ossiferous caves, we find the same group of animals, with the exception of the musk-sheep; and it is therefore evident that the cave-fauna is identical with that of the river strata, and must be referred to the same period. Some few animals, however, which would naturally haunt caves, are peculiar to them, as the cave-bear, wild cat, leopard, &c.

The magnitude of the break in time between the Prehistoric and late Pleistocene period may be gathered also from the disappearance in the interval of no less than nineteen species.

The middle division of the Pleistocene mammalia, or that from which the Pliocene Cervidæ had disappeared, and been replaced by invading temperate forms, is represented in great Britain by the deposits of the Lower Brick-earths of the Thames valley, and the older deposits in Kent's Hole and Oreston. The discovery, by the Rev. O. Fisher, of a flint-flake in the undisturbed Brick-

earth at Crayford, proves that man must have been living at this time. The mammalia from these deposits are linked to the Pliocene by the *Rhinoceros megarhinus*, and to the late Pleistocene by the *Ovibos moschatus*. The presence of *Machœrodus latidens* in Kent's Hole, and of the *Rh. megarhinus* in the cave of Oreston, tends to the conclusion that some of the caves in the south of England contain a fauna that was living before the late Pleistocene age. The whole assemblage of middle Pleistocene animals evinces a less severe climate than in the late Pleistocene times.

The fossil bones from the Forest-bed of Norfolk and Suffolk show that in the early Pleistocene mammalia there was a great mixture of Pleistocene and Pliocene species. It is probable also that the period was one of long duration; for in it we find two animals which are unknown on the continent, implying that the lapse of time was sufficiently great to allow of the evolution of forms of animal life hitherto unknown, and which disappeared before the middle and late Pleistocene stages.

The author criticised M. Lartet's classification of the Late Pleistocene or Quaternary period, by means of the cave-bear, mammoth, reindeer, and aurochs, and urged that, since the remains of all these animals were intimately associated in the caves of France, Germany, and Britain, and, so far as we know, the first two appeared and disappeared together, and the last two lived on into the Prehistoric age, they did not afford a basis for a chronology.

The latest of the three divisions of the British Pleistocene fauna is widely spread through France, Germany, and Russia, from the English Channel to the shores of the Mediterranean. The Middle Pleistocene is represented by a river-deposit in Auvergne, and by a cave in the Jura, in which the presence of the *Machœrodus latidens*, and a non-tichorine rhinoceros, and the absence of the characteristic arctic group of the late Pleistocene, and of all the peculiar animals of the early Forest-bed stage, prove that that era must be Middle Pleistocene. The Early Pleistocene division is represented in France by the river-deposit at Chartres, being characterized by the presence of two non-Pliocene animals, *Trogontherium* and *Cervus varnutorum*.

The Pleistocene mammalia of the regions south of the Alps and Pyrenees present no trace of truly arctic species, the mammoth being viewed as an animal fitted for the climatal conditions both of Northern Siberia and of the southern states of America. It contains *Elephas Africanus* and *Hyæna striata*.

The fauna of Sicily, Malta, and Crete differs considerably from that described above, possessing some peculiar forms, such as *Hippopotamus Pentlandi*, *Myoxus Melitensis* and *Elephas Melitensis*.

The Pleistocene mammalia may be divided into five groups, each marking a difference in the climate:—the first embracing those which now live in hot countries; the second those which inhabit northern regions, or high mountains, where the cold is severe; the third those which inhabit temperate regions; a fourth those which are found alike in hot and cold; and a fifth, which are extinct.

There were three climatal zones, marked by the varying range of the animals:—the northern, into which the southern forms never penetrated, the latitude of Yorkshire being the boundary of the advance of the southern animals; the southern, into which the northern species never passed, a line passing through the Alps and Pyrenees being the limit of the range of the northern animals; and an intermediate area, in which the two are found mingled together.

Two out of the three zones are proved by the physical evidence of the Pleistocene strata.

We see by the discoveries of Dr. Bryce, Mr. Jameson, and others, that the Pleistocene mammalia must have invaded Europe during the first Glacial period before the submergence; for the reindeer and the mammoth have been found in Scotland under the deposits of the Boulder-clay. Dr. Falconer and others have also discovered the latter animal in the Preglacial Forest bed. The Glacial period can therefore no longer be looked on as a hard and fast barrier separating one fauna from another. If man be treated as a Pleistocene animal, there is reason to believe that he formed one of the North Asiatic group, which was certainly in possession of Northern and Central Europe in Preglacial times.

The Pleistocene mammalia may again be divided into three groups—those which came from Northern and Central Asia, those from Africa, and those which were living in the same area in the Pliocene age. Had not the animals which lived in Europe, during the Pliocene age, been insulated from those which invaded Europe from Asia, by some impassable barrier, the latter would occur in our Pliocene strata as well as the former. Such a barrier is offered by the northern extension of the Caspian up the valley of the Obi to the Arctic sea. The animals of Northern and Central Asia could not pass westward until the barrier was removed by the elevation of the sea bottom between the Caspian and the Urals.

The same argument holds good as to the African mammalia, which could not have passed into Sicily, Spain, or Britain without a northward extension of the African mainland.

The relation of the Pleistocene to the Pliocene fauna is a question of great difficulty. If the Pliocene fauna be compared with that of the Forest-bed, it will be seen that the difference between them is very great. The Pliocene mastodon and tapir, and most of the Cervidæ, are replaced by forms such as the roe and red deer, unknown until then; but many of the Pliocene animals were able to hold their ground against the Pleistocene invaders, although they were ultimately beaten in the struggle for existence by the new comers. The fauna which the author adopted as typically Pliocene is that furnished by the lacustrine strata of Auvergne, the marine sands of Montpellier, and the older fluviatile strata of the Val d'Arno.

3. *On Glacier Motion;* by JOHN AITKEN.—In making some experiments on the freezing of water some time ago it was noticed that after the same water had been melted and frozen a number of

times it generally burst the tube in which it was frozen. On looking for an explanation of this phenomenon, it became at once evident that the experiment contained the germ of the explanation of glacier motion. Every time the water was frozen in the tube there was a mimic representation of glacier motion. The ice possessed, the first two or three times it was frozen, a certain amount of viscosity which enabled it to adapt itself to the shape of the tube, as was evident from the distortion of the upper surface of the ice in the tube. How came the ice to lose this plasticity or viscosity, this power of adapting itself to the shape of the tube, the loss of which caused it to burst the tube after it had been frozen and melted a number of times? Wherein did the ice which had only been frozen once differ from the other? The answer to this seemed to be, that the ice which had only been frozen once had more air in it than that which had been frozen and melted a number of times, as each succeeding freezing deprived the ice of a quantity of air or some other gases. The natural conclusion, therefore, seemed to be, that ice with air in it is a viscous substance, though pure ice is not. The first question then to be asked is, is ice with air in it a viscous substance? In order to get an answer to this question, glass tubes ·4 inch in diameter and twelve inches long were filled with water in which was dissolved a great quantity of air. The tubes were then placed in a freezing mixture. After the water was frozen in the tubes the tubes were slightly heated and the rods of ice withdrawn from them and placed on two supports eight and a half inches apart, and a weight of one pound hung from the center of these ice beams. The beams at once began bending and continued bending so long as the weight was left on them, thus proving the viscosity of the ice experimented on. The ice of these beams though similar was not the same as glacier ice; other ice beams were also made, in as close imitation of glacier ice as possible, which was done by placing a small quantity of water in the tubes, then some snow, and pressing it firmly to the bottom of the tubes, then adding more snow, and again firmly pressing it down, and so on till the tubes were filled, as much pressure being applied as possible to the snow to drive out the water. The tubes were then placed for some time in the freezing mixture. The ice beams were afterward withdrawn from the tubes and placed on the supports, and a weight of one pound hung from the center. The beams of snow-ice so made were found to be more easily bent than those made from the water. The rate at which they bent varied, possibly owing to there being more or less water-ice mixed with the snow-ice: one of the beams bent one inch in five minutes. Temperature seemed to have some influence on the rate of bending of these beams, but this point was difficult to determine on account of the different beams bending at different rates at the same temperature; but so far as could be ascertained from the experiments, the beams bent slower the lower the temperature. The lowest temperature used in these experiments was rather more than three Fahrenheit degrees below freezing.

Smaller rods of snow-ice were made ·2 inch in diameter, and as it was found that these could be easily bent in the hand, it was thought possible to bend them into rings. In attempting to bend these rods round a cylinder three inches in diameter, a difficulty was met with. After the pressure had been applied a short time, and before the circle was half turned, the rods always broke with a pressure which they easily bore at the beginning. Here, then, was a difficulty. The explanation seemed to fail at the last moment. The bending had so altered the structure of the ice, that it had lost much of its viscosity and became brittle. How then are we to account for glacier ice keeping its viscosity after years of bending? On examining the fracture of the beams it appeared as if a fibrous structure had been developed in the ice by the bending. The fracture did not go straight across, but part of it ran parallel with the axis of the beam, strongly resembling the fracture of poor bar iron, crystalline at one part, fibrous at another. The bending of the ice had evidently developed a laminated structure in it, similar to that found in glaciers. This laminated structure was developed along the beams, as was to be expected; for the direction in which this structure will be developed depends more on the direction in which the particles of ice are caused to slip over each other, than on the direction in which the pressure or tension is applied. The bending having produced this laminated structure in the ice, it is evident that the beams will be weaker after this structure is developed than before, on account of the cohesion of the ice being weakened along the planes of lamination. It was thought therefore that if the pressure was taken off the ice so as to relieve the particles from strain and stop them sliding over each other, that the laminæ which had been developed in the ice would, so to speak, become welded together, and the strength and plasticity of the beam be restored. Acting on this supposition, an attempt was again made to bend the ice beam into a circle. After a small part of the circle had been turned, the pressure was taken off the beam and a short time given for the particles to rearrange themselves; the pressure was then again applied, a small part more bent, and so on. When done in this way it was found that the ice beams were easily bent into a circle; the ends were then united by means of pressure, and a solid ring was thus produced from a straight beam of ice. These conditions of alternate rest and pressure are in all probability those which exist in glaciers. After pressure has acted at one part of the glacier, bending takes place, so relieving the ice at that part from the pressure, which comes to bear on another part of the glacier; and before the pressure again comes to bear on the first part its strength and plasticity or viscosity has been restored by rest.

Although ice under certain conditions has by these experiments been shown to be a viscous substance, to have the power of changing its shape and so enabling it to flow—though slowly—in its channel; although it has thus been shown that the viscosity of ice is a course of glacier motion, yet it must not, therefore, be conclu-

ded that it is the only cause. Among other causes which may assist in producing glacier motion may be mentioned: 1st. The sliding of the ice over its channel; this sliding being assisted by the tendency which the ice has to melt where it rests on its channel. 2d. The melting of the ice in front of obstacles, the melting being produced by the melting point of the ice in contact with the obstacle being lowered by the pressure of the ice behind. 3d. The melting of the ice in the body of the glacier, by heavy pressure being brought to bear at certain points, part of the water so formed finding its way to the channel under the ice, and part being refrozen. 4th. The crevices in the glacier formed by the fracture of the ice. This breaking up of the ice will enable large masses of ice to move into different positions relative to each other, much more easily than if the ice was solid. This breaking up of the ice will also make the motion due to its viscosity take place quicker than if the ice was in one mass. 5th. The old dilatation theory explains something of the motion of glaciers, though it may not explain how that motion takes place; yet it accounts for some of the pressure which produces that motion.—*Nature*, Feb. 13.

4. *Note on Earthquake Waves;* by J. E. HILGARD, Assistant in Charge, U. S. Coast Survey. (Communicated to this Journal, with the sanction of Prof. Peirce, Director U. S. Coast Survey).—The self-registering tide-gauges, maintained by the U. S. Coast Survey at different points on the sea coast, frequently have exhibited, superimposed upon the tidal fluctuation, a succession of long waves, the origin of which is ascribed to distant earthquakes. In two notable instances, viz., the earthquake of Simoda in 1854, and that of Arica in 1868, the great ocean waves caused by the disturbance were distinctly registered in that way by the tide-gauges on the Pacific coast, and they have been made use of to estimate the average depth along the lines of transmission. See Coast Survey Reports for 1855, '62 and '69.

Similar fluctuations were registered on the morning of the 17th of November, 1872, shortly after local midnight, on the tide-gauge at North Haven, on the Fox Islands, in Penobscot bay, Maine. The fluctuations continued from midnight until nearly six o'clock in the morning, at somewhat regular intervals of about 17 minutes from crest to crest, with an average vertical range of 9 inches, the greatest wave being at three o'clock, with a height of 20 inches.

No corresponding earthquake phenomena have come to the knowledge of the Coast Survey office, and it is probable that if such was the case, the shock occurred somewhere under the Atlantic ocean.

5. *On the age of certain beds of Wyoming referred to the Tertiary by Prof. Hayden and to the Cretaceous by others;* by Prof. LESQUEREUX.—In a paper published as *rectification* by Prof. E. D. Cope, (Feb. 7, 1873,) and distributed as a circular, I read the following remark: "Prof. Lesquereux (Hayden's Survey of Territories, 1870, p. 306) had considered the fossil flora of Point of Rocks,

forty miles westward, as of "unknown age," and those of Evanston as "*Miocene*."

The Report, loc. cit., p. 306, under: "3d column, *Eocene*," has:
"Mississippi flora from Hilgard's and Safford's specimens."
"Marshall mine."
"Raton pass, with Purgatory Cañon and Golden City."
"Washakie station."
"*Evanston*, below coal."
"Evanston, above coal, etc., etc."

Concerning Green river and Point of Rocks, I remark, p. 305: "The fourth section, marked *unknown* has the species from localities not satisfactorily known, either on account of the too small number of specimens representing them, or from want of reliable reference." The description of species of this volume shows that there were then only two species known from Green river: *Ceanothus cinnamomoides*, sp. nov., and *Carya Heerii* Ett., and from Point of Rocks also two species, a *Cyperites* and *Fagus Antipofii* Heer. From this I was not authorized to draw any conclusion. But in the Appendix to the same report, May, 1872, prepared from specimens received after the printing of the first part, twenty-two species are described from Green river, and the General Remarks, p. 17, concludes as follows: "The relation of all these species, except Cyperaceæ, etc., found everywhere, is evidently with younger types and indicates a higher station in the Tertiary measures. From the absence of the species which characterize the American formation considered as Eocene, and also from the absence of Arctic types, which become less predominant in advancing toward our present epoch, the fossil plants of Green river apparently represent the Upper Eocene." Of Point of Rocks station, in same Appendix, p. 18, I described nine species in addition to the two formerly known from report, p. 289, and did not find in this group any species characteristic of a peculiar stage of the Tertiary, only remarking, "that three of these species are represented at Evanston, etc., in strata considered as Eocene, but that from the presence of Arctic types, which are not found at Green river, these strata occupy a lower stage in the Tertiary, though higher than Evanston, and that therefore its place is in the Lower Miocene." And same page 18 of the Appendix, the conclusion of the remarks on Evanston is as follows: "It is undeniable that without any exception, most of these types of ours, compared with European fossil species, should be referable to the Miocene. But, as said in the Report, pp. 313 and 314, either these species belong to the American Eocene, or as yet this formation is unknown in our geology."

These observations do not tend, in the least, to eliminate the priority of Prof. Cope to the discovery of the so-called Cretaceous characters of the group under consideration. These characters have to be critically reviewed in another place. They merely determine positively for future reference the conclusions indicated by botanical paleontology, even from the examination of a limited number of specimens.

Columbus, O., Feb. 15, 1873.

6. *Meek on the Cretaceous in Utah.*—In Dr. Hayden's report for 1870 (Preliminary Report of the U. S. Geol. Survey of Wyoming, &c.), Mr. Meek expresses himself as follows with regard to the Cretaceous age of certain beds at Coalville, Utah.

Some of the specimens from near Bear River, and at Coalville, Utah, from a light-colored sandstone, containing beds of a good qualtity of brown coal, appear to belong to a member of the Cretaceous series not corresponding to any of those named in the Upper Missouri country; though it is, as I believe, represented by a similar sandstone under the oldest estuary Tertiary beds at the mouth of the Judith River, on the Upper Missouri. In 1860 Colonel Simpson brought from this rock, on Sulphur Creek, a small tributary of Bear River, in Utah, some casts of *Inoceramus*, and other fossils; and in some remarks on Colonel Simpson's collection, published by the writer, in connection with Mr. Henry Engelmann, the geologist of Colonel Simpson's survey,* we referred this formation to the Cretaceous. The collections that have since been brought in from it, in Utah, by Mr. King's and Dr. Hayden's Surveys, confirm the conclusion that it belongs to the Cretaceous, as they contain, among other things, species of *Inoceramus*, *Anchura*, and *Gyrodes*—genera that seem not to have survived the close of the Cretaceous period. In addition to this, there is among Dr. Hayden's collections from this rock, at Coalville, a *Turritella* that I cannot distinguish by the figure and description, even specifically, from *T. Martinezensis*, described by Mr. Gabb, from one of the upper beds in California referred to the Cretaceous. A *Modiola* from the same horizon also appears to be specifically identical with *M. Pedernalis* of Roemer, from the Cretaceous of Texas. Dr. Hayden also has, from a little above the coal beds at Coalville, specimens of oyster that seem much like *O. Idriaensis* and *O. Breweri* of Gabb, from the upper beds of the California Cretaceous. As no other fossils were found directly associated with these oysters, however, nor any strictly marine forms above them, it is possible that they may belong to the lower Tertiary.

From the affinities of some of these fossils to forms found in the latest of the beds referred in California to the Cretaceous, and the intimate relations of these marine coal-bearing strata of Utah to the oldest Tertiary of the same region, and the apparent occurrence of equivalent beds bearing the same relations to the oldest brackish-water Tertiary beds at the mouth of Judith River on the Upper Missouri, I am inclined to believe that these Coalville beds occupy a higher horizon in the Cretaceous than even the Fox Hills beds of the Upper Missouri Cretaceous series; or, in other words, that they belong to the closing or latest member of the Cretaceous.

7. *Supplementary Note on the Dinocerata;* by O. C. Marsh.—After the article on page 293 was printed, and copies distributed, another paper by Prof. Cope on the same subject was received (March 20th). In this paper, which is dated March 14th, 1873, and illustrated by four plates, Prof. Cope has at last adopted

* See Proc. Acad. Nat. Sci., Philad., 1860.

nearly all my views as to the characters and affinities of the *Dinocerata*, as well as most of my corrections of his errors, although without giving credit in either case. Unfortunately, he still misinterprets the structure of this group on several points, and most of his dates are as incorrect as before. On nearly every page of the paper, moreover, new errors may be detected, a few only of which can be corrected here for want of space.

1st. Prof. Cope is wrong in assigning only three sacral vertebræ to the *Dinocerata*, as *Dinoceras*, the type of the group, certainly has four, and the other genera probably as many. 2d. The neck in *Tinoceras grandis* Marsh (or ? *Tinoceras cornutus*) was much more than a foot in length, rather than less, as the cervicals in the Yale Museum clearly prove. 3d. Prof. Cope is entirely in error in saying that the muzzle in this species could not reach the ground by several feet; the animal really having no use for the long proboscis which Prof. Cope insists in putting on him. 4th. The specimen described as *Eobasileus cornutus* was fully adult, as the teeth show, and the differences between it and the type of *Tinoceras grandis* may be due to age. 5th. The nasal bones in this genus do not form the inner half of the middle horn-cores, but only a small portion of the base, the cores being essentially on the maxillaries. 6th. The anterior extension of the malar bone is not in *Dinoceras* much less than in the perissodactyls. 7th. The tusks figured in plate I of Prof. Cope's paper are not in their true position, and in plate II the left tusk is placed on the right side, thus entirely reversing its characters. 8th. The name *Loxolophodon* was not applied to the genus *Tinoceras*, Aug. 19th, 1872, but long afterward, and then altered to *Lefalophodon*, with specific names all different from those now claimed. A good example of the inaccuracy which seems inseparable from Prof. Cope's work is seen in the explanation of the plates of this paper, where two serious mistakes occur in the first line.

Prof. Cope concludes with some remarks about nomenclature, evidently aiming to save, if possible, some of his names which are anticipated by mine. His views as to what constitutes publication are absurd, and would not be accepted by any scientific authority. His precepts about describing genera may be fitly compared with his practice, without going beyond the *Dinocerata*. The name *Loxolophodon* Cope was first given, without description, to a genus which Prof. Cope now rejects, and when again applied, contrary to usage, to the genus *Tinoceras*, all the generic characters mentioned existed only in that author's imagination.

Yale College, March 22d, 1873.

8. *Notice of Fossil Vertebrata from the Miocene of Virginia.*— Prof. LEIDY directed attention to some fossils, part of a small collection recently received. They were found imbedded in blue clay containing an abundance of fossil diatomes, among which Coscinodiscus is especially conspicuous. The fossil vertebrate remains consist mainly of vertebræ and teeth of cetaceans, vertebræ of bony fishes, teeth of sharks, and spines of rays. Among them

also there is a portion of a humerus of a bird, and several worn teeth of a peccary. Besides these there are specimens which may be regarded as characteristic of the following undescribed species.

Protocamelus Virginiensis. Represented by the lower last premolar, and the first and last molars of an animal about the size of the existing Lama, and intermediate in size to *Protocamelus occidentalis* and *P. gracilis* of the tertiary of the Niobrara river, Nebraska.

Tautoga (*Protautoga*) *conidens.* Represented by a premaxillary with teeth, and portion of another with the first tooth. The specimens indicated a much larger species than the living Black Fish, *Tautoga.* The bones and relative position of the teeth exhibit some peculiarities. The premaxillary externally is flatter than in the Black Fish, and it appears as if it had not turned down in a hook-like end at its outer extremity. The teeth also are separated by comparatively wide intervals, independently of the interspaces provided for successional teeth. The form of the teeth is the same as in the Black Fish. One of the specimens contains the base of the first large tooth, and a row behind of seven other teeth. The other specimen contains the first large tooth, which is nearly half an inch in length, but proportionately more robust than in the Black Fish.

Acipenser ornatus. Founded on a dorso-lateral plate indicating an extinct species of sturgeon of medium size. The length or height of the plate is about 2½ inches; its breadth along the crest is an inch and three-fourths.—*Proc. Acad. N. S. Phil.*, 1872.

10. *Henry Woodward on Coal-measure Spiders.*—In the autumn of 1871, Mr. Woodward described, in the Geological Magazine, a very perfect specimen of spider from the Coal-measures of Dudley, which he named *Eophrynus Prestvicii.* In the same magazine, for Sept., 1872, he announced the discovery of another species, from Lancashire, occurring in the iron-stone and Coal-measures of that county. The specimen is 16 millimeters long and 7 broad. He referred it to the genus *Architarbus* of Scudder, and named it *Architarbus subovalis.* Scudder's species, *Architarbus rotundatus* was found in an iron-stone nodule at Mazon Creek, near Morris, Grundy Co., Illinois, and is described and figured in the 3d volume of Worthen's Illinois Geological Report (1868).

11. *A Monograph of the British Fossil Crustacea belonging to the order Merostomata;* by HENRY WOODWARD. (Printed for the British Paleontological Society). Part IV of this very valuable monograph was published during the past year. It contains descriptions of species of *Stylonurus*, *Eurypterus* and *Hemiaspis*, with wood-cuts and several lithographic plates, giving full-sized representations of these remarkable species. *Eurypterus ?* (*Arthropleura*) *ferox* of Salter, from the nodules in the Coal-measures of Tipton, Staffordshire, is probably, according to Woodward, a Myriapod of the genus *Euphoberia* of Meek and Worthen.

12. *Naumann on Pseudomorphism.*—In the December number, 1872, of the *Jahrbuch für Mineralogie und Palæontologie* of

Leonhard and Geinitz (which monthly Journal, by the way, contains the fullest record of new discoveries and observations in mineralogy and geology in any scientific periodical), Naumann has a letter correcting in strong language the statement of his views on pseudomorphism made by Prof. T. Sterry Hunt before the American Association in 1871. The letter closes with the remark that "only an incomprehensible misunderstanding can account for his statement, which has been already sufficiently refuted by Dana in the American Journal of Science for February and August of 1872."

13. *The Geological and Natural History Survey of Minnesota.* First Annual Report for 1872, by N. H. WINCHELL, State Geologist., St. Paul, Minn., 1873.—Prof. Winchell prefaces his valuable report by a list of the published books and articles that bear on the Geology and Natural History of the region, commencing with Father Hennepin's work published in 1679, and adding some notice of their contents. The topography of the State is described and the heights along various railroad lines are given. The distribution and relations of the several geological formations are briefly explained, and illustrated on a colored "preliminary geological map" of the State. This map shows that the Archæan (Azoic) rocks which border the west shore of Lake Superior extend southwestward through the middle of the State, and also along its northern border. East and west of the central Archæan axis there are the successive formations of the Lower and Upper Silurian, commencing with the Potsdam Sandstone; but those of the Upper Silurian have not yet been particularly studied. The Devonian is not known to be represented, although supposed to exist. In addition, the author describes the Cretaceous formation as covering most of the southern half of Minnesota, and probably a wide belt along its western border reaching to the United States boundary. The eastern limit of the Cretaceous is still uncertain. He supposes that it may formerly have overlaid a large part of the Archæan region. The report closes with a list of herbaceous plants in the vicinity of St. Anthony, drawn up by Prof. E. H. Twining.

14. *Large Diamond.*—A diamond weighing 288½ carats and of the first water, was found Nov. 6th, 1872, at Waldeck's placer, Vaal river, South Africa, by Robert Spaulding's party. It is stated to measure about 1⅛ inch in diameter. If this statement is confirmed the Waldeck-Spaulding diamond is among the largest rough diamonds of which we have mention. The Regent weighed 410 carats (136$\frac{14}{16}$ cut), and the Great Mogul 780½ carats (279$\frac{9}{16}$ cut). A diamond in the possession of the Rajah of Maltan in Borneo, weighs 367 carats; the Nizam belonging to the king of Golconda weighs 340 carats. The Mining and Scientific Press of Feb. 22, gives a figure of the Waldeck-Spaulding stone, taken from a photograph, which shows its form to be an irregular octahedron.

15. *Trautwinite.*—E. GOLDSMITH has thus named (Proc. Acad. N. Sci. Philad., 1873, p. 9), a green mineral occurring in micro-

scopic hexagonal crystals (pyramids with the prism, the latter sometimes 3-sided) on chromite from California, specimens of which he received from Mr. John C. Trautwine. Chemical and blowpipe examination showed that it contained oxides of chromium, iron and magnesium. Heated to redness in the closed glass tube, it gave a little water and turned bluish green. Not dissolved in acids.

16. *Mineralogische Notizen*, von FRIEDERICH HESSENBERG. No. 11. (From vol. viii, of the Abhandlungen of the Senckenberg Natural History Society of Frankfort.)—Hessenberg continues here his crystallographic researches. He describes crystals of perofskite from Pfitschthal, of calc spar from Iceland and Andreasberg, and others of sphene and axinite; indicating for sphene some evidence of hemimorphism.

17. *The Sexes of Sphæroma;* by OSCAR HARGER.—In a recent memoir on Crustacea of the Coast of France, published in the Annales des Sciences Naturelles, 5e série, tome xvii, 1872–3, M. Hesse has, with considerable hesitation, advanced the opinion that *Spœhroma* is only the female of *Cymodocea*, and that *Dynamene* is the female of *Næsea*. The hesitation of this author rests upon the fact, that the evidence in his possession was unsatisfactory and negative in character; and he laments his ill success in raising the young of these animals, significantly remarking of the offspring of *Sphæroma*, which he raised as far as the third moult, "Lorsque ces Crustacés sont parvenus à ce degré de transformation, ils ont la forme de leur mère, c'est-à-dire celle des *Sphéromiens*." In the case of *Dynamene* and *Næsea* less hesitation is expressed, and the absence, so far as known, of the former genus from this coast, cannot be considered as conclusive against the proposition. Neither has *Cymodocea* yet been obtained so far as I know on our coast, but *Sphæroma quadridentata* Say is not uncommon on the coast of New England south of Cape Cod, and, in any considerable collection of these animals, both sexes may be easily found. The sexes are readily distinguished by the second pair of pleopoda which, in the males, are furnished with a slender style, articulated to the inner or posterior lamella, and lying along its inner side. Near the middle of the ventral surface of the seventh thoracic segment of the males are two short, movable processes. In the females the plates, which during the breeding season are developed for the purpose of carrying eggs, are at other times small, and may be difficult of observation, but can usually be found as slender processes from the basal joints of the legs. Except in these sexual characters the two sexes closely resemble each other, and both belong to the genus *Sphæroma*.

18. *Key to North American Birds, containing a concise account of every species of Living and Fossil Bird, at present known from the Continent north of the Mexican and United States Boundary;* by Dr. ELLIOTT COUES, U. S. A. Large 8vo, 361 pages, with 6 steel plates and over 250 wood-cuts. Naturalist's Agency, Salem, Mass.—This is an excellent manual of North American ornithology, suitable for beginners in the science, and useful and con-

venient for those who are already proficient. It is beautifully printed on heavy paper, and the illustrations are appropriate and well executed. The typography of the work does great credit to the "Salem Press," where it was printed.

In the first part of the book the author describes and illustrates the plumage of birds, and gives an account of their external characters and anatomy, together with such explanations as seem necessary in respect to the principles of classification, etc.

This is followed by an artificial key to all the genera, which will be especially useful to those who are beginning the study by themselves.

The greater part of the volume is taken up by the systematic synopsis of the birds. In this part the author has given clear and concise descriptions of all the species, and generally of both sexes and the young, with their geographical range, and references to the principal works where they are described and figured. The descriptions of the genera and higher groups are also good. The syonymy has been mostly omitted. The synopsis of fossil species contains brief notices of the species hitherto described, with references to the original descriptions. This part has already been noticed in this Journal. A copious combined index and glossary closes the volume, which we heartily welcome as a very important addition to our educational works in Natural History. A. E. V.

19. *Arrangement of the Families of Fishes, or Classes Pisces, Marsipobranchii, and Leptocardii;* by THEODORE GILL. 8vo, 95 pages, Smithsonian Miscellaneous Collections.—This work consists, 1st, of an introduction in which the classification of fishes is discussed at considerable length, and the views of various other writers are presented, together with a discussion of the homologies of the Shoulder Girdle and Pectoral Limb; 2d, a list of the families and higher groups; 3d, a very useful Bibliography of the most important general descriptive works on Ichthyology; 4th, an alphabetical index to the names of families and other groups. As indicated by the title, Professor Gill recognizes among the so-called fishes three distinct classes of vertebrates. These classes do not, however, correspond to those recognized by Professor Agassiz. The former unites the Selachians, Ganoids and Teleosts as sub-classes of the class Pisces; while the latter has proposed to consider them as distinct classes. The following are the higher divisions adopted by Professor Gill:

Class Pisces.
- Series I.—Teleostomi or Branchiata.
  - Sub-class 1.—Teleostei, including 9 orders.
  - Sub-class 2.—Ganoidei, including 6 orders.
- Series II.—Elasmobranchii.
  - Sub-class 3.—Elasmobranchii, including 3 orders.

Class Marsipobranchii.
- Orders Hyperoartii and Hyperotreti.

Class Leptocardii.
- Order Cirrostomi.

20. *Arrangement of the Families of Mammals, with Analytical Tables;* by THEODORE GILL. 8vo, 98 pages, Smithsonian Miscellaneous Collections, November, 1872.—This work is still incomplete. The part published contains, 1st, a list of the families and higher groups of mammals, with some of their synonyms; 2d, Bibliography of the works referred to; 3d, Synoptical Tables of Characters of the subdivisions of Mammals, with a catalogue of the Genera.

The Synoptical Tables are completed only to the end of the Cete. This part of the work gives a very convenient epitome of the principal characters of the groups, and it is to be hoped that it will soon be completed.

The classification will be indicated by the following table of the higher groups:

Sub-class I.—Placentalia or Monodelphia.

Super-order 1.—Educabilia (=Megasthenes Dana).

Eight orders: Primates; Feræ; Ungulata; Toxodontia; Hyracoidea; Proboscidia; Sirenia; Cete.

Super-order 2.—Ineducabilia (=Microsthenes Dana).

Four orders: Chiroptera; Insectivora; Glires; Bruta.

Sub-class II.—Didelphia.

Order Marsupialia, with four sub-orders.

Sub-class III.—Ornithodelphia.

Order Monotremata, with two sub-orders. A. E. V.

21. *Fertilization in Grasses.*—Professor HILDEBRAND of Freiburg made to the Berlin Academy a detailed communication on this subject, which is published in its Monatsbericht, Oct., 1872. He shows that there is an entire series of steps from the completely dicœcious arrangement to that in which self-fertilization is the rule even if it has exceptions. There are, for instance, some examples of dicœcious grasses, then a number of monœcious, after which follow some with both hermaphrodite and staminate flowers, where the latter only can serve for crossing; then, in greater number, grasses with purely hermaphrodite flowers; in some of which the pistil develops before the anthers; in others, where the pistil and anthers develop simultaneously, the discharge of pollen from the anthers lasts for an appreciably longer time; but there are some cases where the pistil and anthers appear to develop together and have the same duration, but yet under such conditions that the pollen can reach the pistil only with difficulty. And finally some grasses in which close fertilization is not avoided, but actually occurs in a large proportion of cases, and even preponderates; yet even in these instances occasional cross-fertilization does not appear to be excluded

So that fertilization in grasses, as in other families of plants, must be studied, species by species, and we cannot apply our observations of one species to another species even of the same genus. Thus the genera *Hordeum*, *Avena* and *Triticum* exhibit great diversities in respect to fertilization in their several species.

A. G.

III. Astronomy.

1. *Meteors of November 27th, 1872, and Biela's Comet.*— From various parts of Europe the accounts of the meteors continue to come to us. Schiaparelli and Padre Denza have given to the *R. Inst. Lombardo* a summary of the observations received by them (*Rendiconti*, vol. 5, Fasc. 20), and Prof. Tacchini has published those made in Sicily. In the *Wochenschrift* Prof. Heis has published a large number of accounts, especially those of observers in Germany.

One interesting question, whether or not the comet observed by Pogson at Madras on the 2d and 3d of December can be one of the fragments of Biela's comet, is discussed by Klinkerfus (*Astron. Notices*, Jan., 1873), Peters, Holetschek and Oppolzer (*Astron. Nach.*, 1917 and 1920). Perhaps the most satisfactory treatment of the question is by Oppolzer. It will be recollected that Pogson made two observations, at about 24 hours intervals, and that the comet during that time moved 1° 40′ in declination, and $14^m\ 36^s$ in right ascension. More places are needed to give the orbit of the comet. Can these two be represented by an orbit like that of Biela? On the one hand, Klinkerfus asked Pogson to look near *Theta Centauri* for the comet; he looked, and saw it. On the other hand, the direction of the motion is rapid, and is neither from nor to the point opposite to the radiant in Andromeda. Again, this comet was twelve weeks behind the computed places of Biela. Prof. Oppolzer, at the request of Dr. Weiss, examined the observations, beginning his work with the impression that the Pogson comet was not one of Biela's, but he became convinced by the result of his computations that the likeness of the elements which he obtained to those of Biela could not be the result of chance.

It seems to us extremely improbable that the comets have lost twelve weeks, as there have been apparently no large doubtful perturbations. Through the last 20 years Jupiter has kept at a considerable distance from them, and his influence has been allowed for. The natural deduction is, as stated by Mr. Proctor, that what Mr. Pogson saw was a meteoric aggregation traveling on the track of the comet, but far behind it. In fact, it seems to be a third piece of Biela's original comet, separated from the main body, perhaps, long ago. The size of the nucleus seen by Mr. Pogson was comparable to that of the moon, allowing for the probable distance of the comet. It took us over six hours to cross the dense part of the meteor stream on the 27th of November. Had its thickness been only equal to that of the moon's diameter, the shower would have lasted about 10 minutes.

The meteors seen on the evening of Nov. 24th appear to have belonged to still another stream of fragments from Biela's comet, since they were not to be seen in so great numbers on the evening of the 25th. Possibly the Pogson comet belonged to that stream.

Capt. Tupman suggests that the two observations of Mr. Pogson were of the two different known parts of the comet.

The brilliant shower, and the subsequent appearance of the comets, cannot fail to recall the closely analogous case of the shower of 1366, and of the two comets seen immediately thereafter, traveling apparently in the path of the meteoric stream.* In that case, however, the comets were seen after the earth passed the node, but before the comets reached it. H. A. N.

2. *Meteor in Kentucky, Dec. 12th*, 1872.—Under date of Dec. 12th, Prof. Kirkwood writes: "At 4^h 53^m this evening (just after sun-set), I saw a magnificent meteor. It was observed through a southern window, and came into view about 15° east of the meridian, at an altitude of 40° E. Its course was east of south, making an angle of 60° with the horizon. Its light was intensely brilliant. It exploded at an altitude of 10°, but I heard no report."

Prof. Kirkwood has also sent several notices from the papers. The *Lebanon Standard* (Marion Co., Ky.), says that a bright white light was seen in a N.W. or N.N.W. direction at an elevation of about 45°, at first inclined to the horizon but almost instantly assuming a position perpendicular to it. The smoke remained several minutes, separating into parts and fading away. An explosion was heard in Georgetown, Ky.

A letter from Prof. White, of Lexington University, states that it was seen (by a person five miles N.W. of that city) to pass from a point probably about 30° west of the zenith, to a point nearly southwest of the observer. A heavy explosion was heard five minutes after the disappearance of the meteor. The cloud remained several minutes.

The various accounts are conflicting, but are best explained by a meteor moving about S. 45° E., and exploding at an altitude of about 20 miles. The inclination to the horizon is quite uncertain, probably not less than 30°, and not more than 60°. If fragments came to the earth, it was probably in a district northwest of Lebanon, and not more than twenty or thirty miles from that place. H. A. N.

3. *Double Meteor of Feb. 14th*, 1873.—A meteor, or rather a small group of meteors, appeared near the planet Venus, as seen at New Haven, just after the clock struck six on the evening of Feb. 14th. They moved northward and downward to an altitude of 15°, in the direction N. 64° W. Mr. William C. Wood, who was with the writer, saw them during about ten degrees of their track; I saw them only for an instant. There were two balls, the leading smaller one being bright green, and the following one of a yellowish color. Other observers saw three balls. From the principal ball Mr. Wood saw sparks separate. It was less brilliant than Venus. The same meteor was seen by Rev. Mr. Middleton at New Britain, who saw it divide into two large portions, and one or two smaller ones. The small soon vanished, while the two large ones passed on.

* This Journal, II, xlv, 91.

This meteor must have been seen at many places west of New Haven, and accounts of its appearance elsewhere are respectfully solicited. H. A. N.

4. *Astronomical Engravings from the Observatory of Harvard College.*—Eighteen plates have been issued out of the thirty promised (vol. iv, p. 243), from the Observatory of Harvard College. The first two plates contain eight views of Jupiter, taken last spring. They exhibit minutely the structure of the belts, and especially the red equatorial belt, a feature very conspicuous then, but now, as Prof. Winlock informs us, no longer visible. There are four plates containing twelve views of the whole solar disk. Among them those which are copied from photographs made by a stationary telescope of long focal distance should be especially noticed. Plate 5 gives six views, on successive days, of a notable sunspot with its bridges, or tongues of light, its faculæ, and its other features, and plate 14 gives other sunspots. Three plates are devoted to various forms of solar prominences. There are three plates giving eleven views of lunar mountains. A fine view of Saturn, two copies of Eclipse photographs, and one plate giving views of the Spectroscopes used, make up the list of plates thus far published.

We most cordially commend these engravings. A teacher of a class in Astronomy could not find in any other form, for the same price (ten dollars), that which will help him so much in his work, as a set of them. If he has a telescope, the engravings suggest the points to be looked at, and if not, they are the very best substitutes we know of for the direct views of the heavenly bodies. They are, we understand, to be accompanied by explanatory notes. H. A. N.

5. *A new method of viewing the Chromosphere.*—Mr. Lockyer and Mr. Seabrooke have sent to the Royal Society a description of a proposed instrumental arrangement for viewing and photographing the chromosphere. The light of the sun is cut off by a circular disk, and the annulus surrounding the disk is viewed by the spectroscope. Drawings made by the new method were exhibited to the Society.

6. *The Chromosphere visible in small telescopes.*—It is a common idea that the hydrogen jets and clouds upon the border of the sun can be seen only through large instruments. Capt. Tupman has communicated to the Royal Astronomical Society a series of observations made by him with a three-inch telescope of indifferent character, and a direct vision five-prism spectroscope. The cost of the entire combination, including stand, was only 18 pounds.

7. *Papers relating to the transit of Venus in* 1874; Part II. 4vo, pp. 48, and 4 plates.—Mr. G. W. Hill, of the Nautical Almanac office, prepared, under the direction of Prof. Coffin, charts and tables for facilitating the prediction of the several phases of the transit of Venus. They were computed from Mr. Hill's Tables of Venus, and were intended as a supplement to the

Nautical Almanac, but were transferred to the Transit Commission, who published them. The four large charts accompanying the paper are suited to the use of navigators who may wish to observe the transit. They are, we may observe, remarkably fine specimens of map printing, the work, if we are not mistaken, of Mr. Bien.

8. *On the Auroral Spectrum.*—A letter from Henry A. Rowland, at present Instructor in Physics in the Rensselaer Polytechnic Institute at Troy, informs us that he observed the line of wave-length 431 in the auroral spectrum of last October. He says: "The observations were made with an ordinary chemical spectroscope of one prism, in which the scale was read by means of a lamp. Great care was taken in the readings, and after completing them the spectroscope was set aside until morning, when the readings were taken on the lines of comparison without altering the instrument in any way or even regulating the slit. The wave-lengths of the known lines were taken from Watts's 'Index of Spectra,' but as he does not give the wave-lengths of lines in the flame spectrum I am not quite certain that they are correct." On the scale of his instrument, Li α was at 13·5°, Ca α 21°, Na α 27·5, Ca β 36°, Ca γ 95·5°, and K β 110°. The aurora lines were as follows:

	Scale-reading.	Wave-lengths.
1	19	628·3
2	35·5	554·3
3	95	425

"The wave-lengths of the auroral lines were obtained by graphical interpolation on such a large scale as to introduce little or no error." G. F. B.

9. *Reports on Encke's Comet, and other reports from the U. S. Naval Observatory.*—From Admiral Sands we have received at different times the 2d, 3d, and 4th Appendices to the volume of observations for 1870, and the 4th Appendix for the volume for 1871, of the U. S. N. Observatory.

The 2d Appendix consists of reports by Professors Hall and Harkness on Observations of Encke's Comet during its return in 1871. Prof. Hall gives the positions of the comet, notes of its appearance, and four drawings of it. Prof. Harkness gives his observations upon the spectrum of the comet, followed by a discussion of the probable mass of the comet, and the density of the supposed resisting medium of space. The following is the general summary of his results:

(1.) Encke's comet gives a carbon-spectrum.

(2.) From November 18th to December 2d the wave-length of the brightest part of the second band of the comet's spectrum was continually increasing.

(3.) No polarization was detected in the light of the comet.

(4.) The mass of Encke's comet is certainly not less than that of an asteroid.

(5.) The density of the supposed resisting medium in space, as computed from the observed retardation of Encke's comet, is such

that it would support a column of mercury somewhere between $\frac{220}{10^{17}}$ and $\frac{285}{10^{20}}$ of an inch high.

(6.) There is some probability that the electric currents which give rise to auroras are propagated in a medium which pervades all space, and that the spectrum of the aurora is, in reality, the spectrum in that medium.

(7.) It it not improbable that the tails of all *large* comets will be found to give spectra similar to that of the aurora, although additional lines may be present.

The *Third Appendix* is by Prof. Newcomb, on the right ascensions of the equatorial fundamental stars. His object is to do for the right ascensions of the equatorial and zodiacal stars, on which the reductions of lunar and planetary observations depend, what has been done by Dr. Auwers for the declinations, namely, to furnish the data necessary to reduce the principal original catalogues of stars to a homogeneous system by freeing them of their systematic differences. He gives a table of the right ascensions of the twenty-seven stars considered for each fifth year from 1750 to 1900, and the corrections for reducing the positions given in the several catalogues to the mean system.

The *Fourth Appendix for* 1870 contains reductions of zones of stars observed with the transit instrument in 1846, '47, '48, and '49. The corresponding observations of the zones with the mural circle were published as Appendix II. of the volume for 1869. The reductions in both cases were made principally by Dr. Gould, and the numbers of stars included in the two series are 12,033 and 14,804 severally, most of them being between 20° and 45° south declination.

The *fourth* appendix for 1871 is a memoir on the founding and progress of the U. S. N. Observatory, by Prof. J. E. Nourse.

The course of Admiral Sands in encouraging the professors in the observatory to bring out in their own name special researches, deserves a creditable notice. H. A. N.

10. *Note Spettroscopische sul Sole e gli altri corpi celesti;* by P. A. Secchi.—This is a reprint of the original Spectroscopic Notices published by the author at various times, and in various journals, since the discoveries of Janssen and Lockyer in 1868.

11. *The Astronomische Nachrichten* will hereafter be sent from Kiel instead of Altona. Communications and subscriptions should be addressed to "*Professor C. A. F. Peters, Kiel, Sternwarte.*" (The subscription price is $3\frac{2}{3}$ dollars, gold.)

IV. Miscellaneous Scientific Intelligence.

1. *The California Academy of Sciences* has received from Mr. James Lick, a magnificent gift of a building site in the city of San Francisco, valued at about $100,000. By the terms of the gift it is required that the building to be hereafter erected upon it shall cover a space of 80 by 225 feet, be of three stories in height, built of brick with granite front, and ornamented with

scientific emblems; and the funds for this building must be secured within two years from the date of the deed. It is necessary to obtain about $100,000 in money to secure this gift, and the Academy have accepted the land in the conviction that they can raise the money. As remarked by the Mining and Scientific Press, Mr. Lick deserves the hearty thanks of the workers in the cause of science all over the world, since he has opened his purse spontaneously to give aid to the cause of science.

2. *The Owens College Junior Course of Practical Chemistry;* by FRANCIS JONES, Chemical Master in the Grammar School, Manchester. With a Preface by Professor Roscoe, F.R.S. 18mo, pp. viii, 171. London and New York, 1872. (Macmillan & Co.)—This little book is not offered as an exhaustive analytical manual, but aims to give only so much instruction as is needed by the average undergraduate student to make the reasoning in his course of chemical study intelligible. Hence the plan of the book is simple. Part I. is devoted to the preparation of and to experiments upon the different gases and some of their compounds. Part II. is devoted to blowpipe analysis; the section on Bunsen's flame-reaction, being most excellent. Part III. is occupied with the reaction of the metals, and Part IV. with those of the inorganic and organic acids and of the alkaloids. Part V. treats of the reactions of the rare metals, and an Appendix contains a table of the elements and a series of questions and exercises upon the entire book. With the able assistance of Professor Roscoe and of Dr. Schorlemmer, Mr. Jones has given us a valuable book, and one which has a most useful place to fill in instruction. We commend it to every teacher who can offer to his class any facilities for the practical study of chemistry. G. F. B.

3. *The Ancient Stone Implements, Weapons, and Ornaments of Great Britain;* by JOHN EVANS, F.R.S., F.S.A., etc., pp. 640, 8vo, with 476 wood-cut illustrations. New York, 1872. (D. Appleton and Company).—This extended monograph gives evidence of most careful study. It is a model for similar labors in other countries, and all who follow Mr. Evans in this line of work will be spared much preliminary labor in comparison and research, as well as in the classification and systematizing of materials so varied and yet so great. His book will be read with pleasure for its instruction, and referred to as an authority. The arrangement of the text is clear and methodical and copious indexes, general, geographical and topographical, with an analytical table of contents, render it of easy reference. The wood-cut illustrations show well the peculiarities of the implements represented, and are nearly all original. We know of nothing of the kind better done.

4. *Evolution of Life;* by HENRY C. CHAPMAN, M.D., member of the Academy of Natural Sciences, Philadelphia. 194 pp. 8vo. Philadelphia, 1873. (J. B. Lippincott & Co.)—This work is devoted mainly to illustrating the fact of the evolution of the systems of life, and to a display of the supposed succession of groups in the progressing evolution. The determination of the order of succes-

sion in the progress of life on the globe is one of the great objects of geological investigation, and is daily being furthered by new accessions of facts; but we think it too soon to make out genealogical trees with the detail attempted by the authorities followed in this work. He has high authority for tracing the vertebrates down to the Ascidians; but we believe, with Prof. Verrill, the conclusion to be based on a wrong idea of the structure of the latter class of animals. There is much that is interesting in the work; yet there appears to us to be too many "non sequiturs" to satisfy strict science. The volume has, as its frontispiece, a map entitled a "Hypothetical Sketch of the Monophylitic Origin, and of the Diffusion of the 12 varieties of Men from Lemuria over the Earth" ("Lemuria" being the supposed birth-continent of man, so named by Sclater from the Lemurs of Madagascar and the Indian Archipelago, and by him located in the ocean between Southern Asia and Eastern Africa); it appears to us to be *very* hypothetical. The work is illustrated also by a number of plates representing the structure and relations of various species of plants and animals.

5. *Address before the Royal Society of New South Wales, at the Anniversary meeting in* 1872, by the Rev. W. B. CLARKE, F.G.S., Vice-President.—The Rev. Mr. Clarke, during the past thirty-five years a resident of New South Wales, has labored assiduously and successfully in the geological exploration of the country, and has perhaps done more than any one else in bringing to light its mineral resources. Even as early as 1841 he proved the existence of gold by discovering it in the granite rocks of the interior of New South Wales. The address, in connection with its Appendix, reviews many of the facts connected with the diamond and gold fields and tin and copper mines of Eastern Australia and some other British Colonies, and the results of recent explorations in Queensland.

6. PROF. TYNDALL'S *works.*—The recent visit of Prof. Tyndall to the United States has naturally excited a fresh interest in his works. Messrs. Appleton have published the following works of Prof. Tyndall.

I. Heat as a mode of motion. 1 vol., 12mo.

II. On Sound. A course of eight lectures delivered at the Royal Institution of Great Britian. 1 vol., 12mo.

III. Fragments of Science for Unscientific People. A series of detached essays, lectures and reviews. 1 vol., 12mo.

IV. Light and Electricity. Notes on two courses of lectures before the Royal Institution of Great Britain. 1 vol., 12mo.

V. Hours of Exercise in the Alps. 1 vol., 12mo.

VI. On Radiation. The "Rede" Lectures, delivered in the Senate House before the University of Cambridge, England, etc. 1 vol., 12mo.

VII. Forms of Water, in Clouds, Rain, Rivers, Ice and Glaciers, with a portrait of the author. 1 vol., 12mo.

VIII. Contributions to Molecular Physics in the domain of Radiant Heat. 1 vol., 8vo.

The same publishers have just now issued Prof. Tyndall's lectures in this country, in a duodecimo volume with numerous illustrations.

OBITUARY.

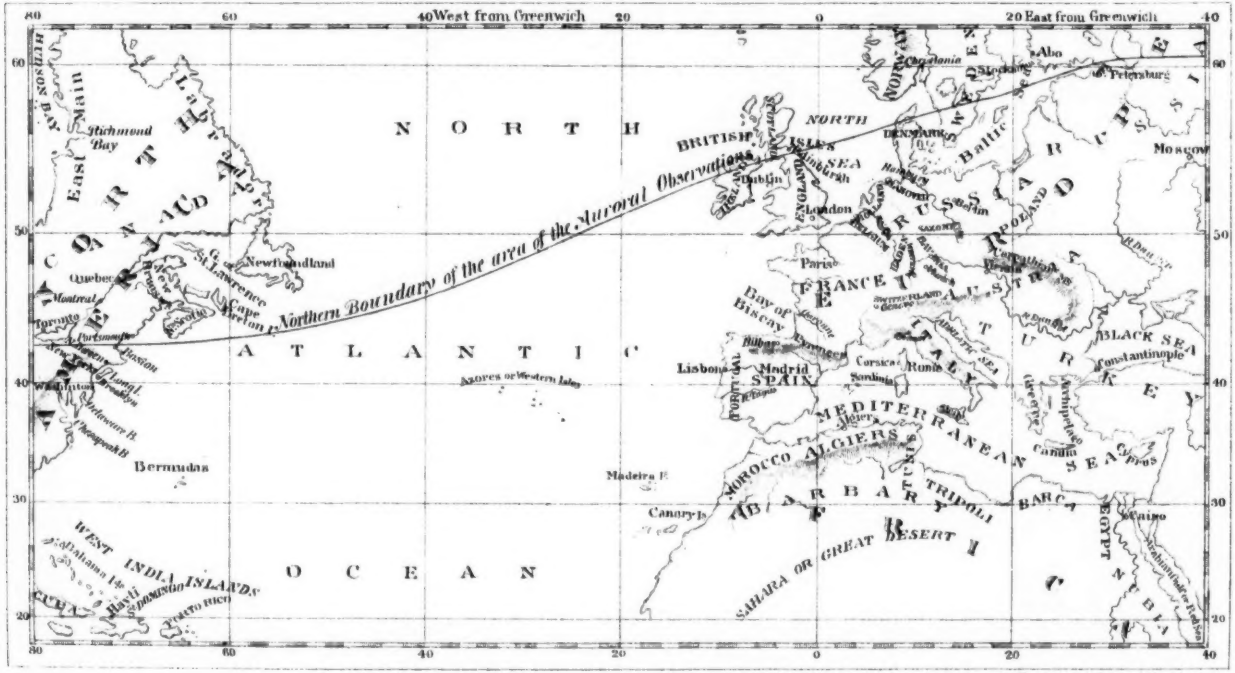
Dr. John Torrey.—Dr. Torrey died of pneumonia at his house, Columbia College, New York, on Monday, March 10th, at the ripe age of 77 years. He was born in New York, August 15th, 1796. He was universally beloved by all who knew him for his genial and truthful qualities, and equally respected for his high intellectual and moral powers and his solid attainments in various sciences. Immediately after his graduation in medicine he entered upon the study of mineralogy, chemistry and botany, the three sciences to which he devoted his life. His first botanical memoir, a list of the plants growing within thirty miles of the city of New York, was published, and his mineralogical contributions commenced, a little earlier. He was one of the founders and presidents of the New York Lyceum of Natural History, in the Annals of which some of his earliest papers appeared. He was made Professor of chemistry in the United States Military Academy at West Point in 1824, where he remained only three years, preferring the same chair in his Alma Mater, the College of Physicians and Surgeons in New York, where he entered upon his duties in 1827 and remained a most successful and honored teacher of his favorite science until 1854. During a portion of this time he also discharged the duties of the chemical chair in Princeton College, New Jersey. In 1853 Dr. Torrey became chief assayer of the U. S. Assay Office in New York, having refused the more responsible and remunerative position of Director from a characteristic unwillingness to enter upon duties which, in his judgment, required business qualities he did not possess. In this office he remained until the end, having signed his last report on the morning of Monday, only a few hours before his death.

In chemistry Dr. Torrey labored much in the laboratory, but he published little, his extreme modesty and conscientious desire for perfection seeming constantly to restrain his pen. His memoir on pectic acid in Tuckahoe or Indian-bread (*Sclerotium giganteum* Torr.) in 1827, and his early researches on the liquefaction of gases are evidence of his accuracy and zeal. He was well known to all students in mineralogy and chemistry for his acute perceptions and minute knowledge of the existing state of these sciences, in which he kept himself always well read up.

But the most important and numerous contributions of Dr. Torrey to science were made in the the department of Botany, of which he was an assiduous and most successful student up to the close of his life. Dr. Torrey's labors in this science will be chronicled in these pages by his fellow worker in the same field, Dr. Asa Gray, whose name is intimately associated with his in the history of American botanical science.

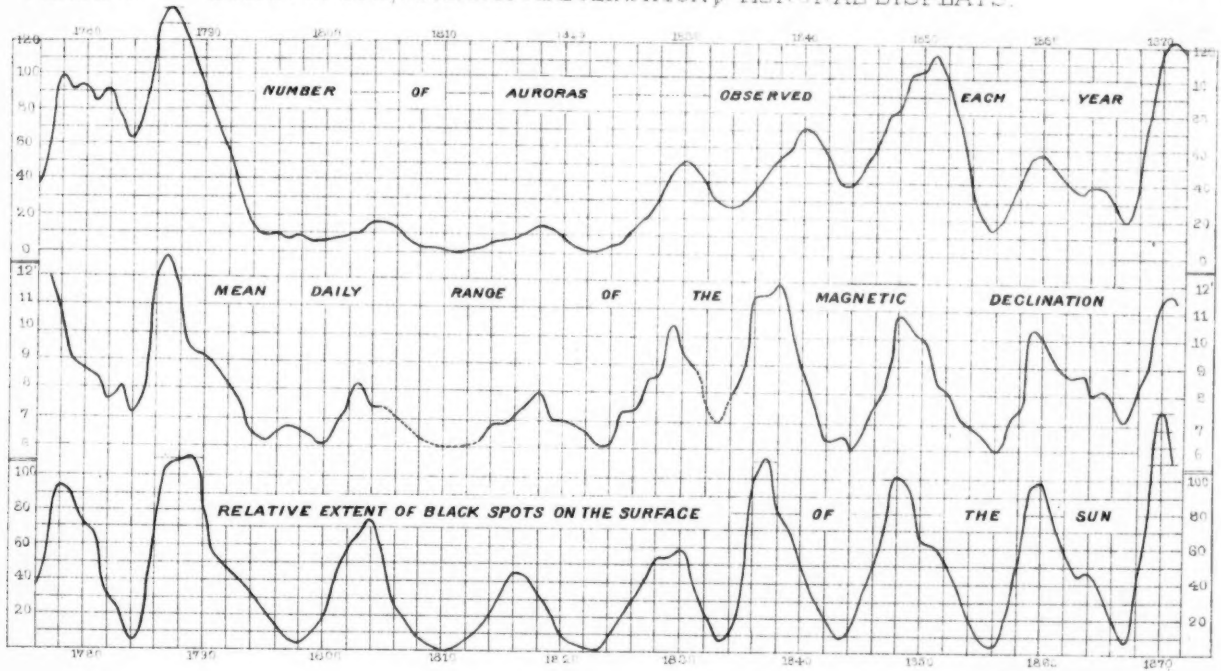
Dr. Torrey leaves one son, who was his official associate, and three daughters, all noted for their varied learning. B. S.

PLATE I. CHART, SHOWING THE AREA OF THE AURORAL OBSERVATIONS.

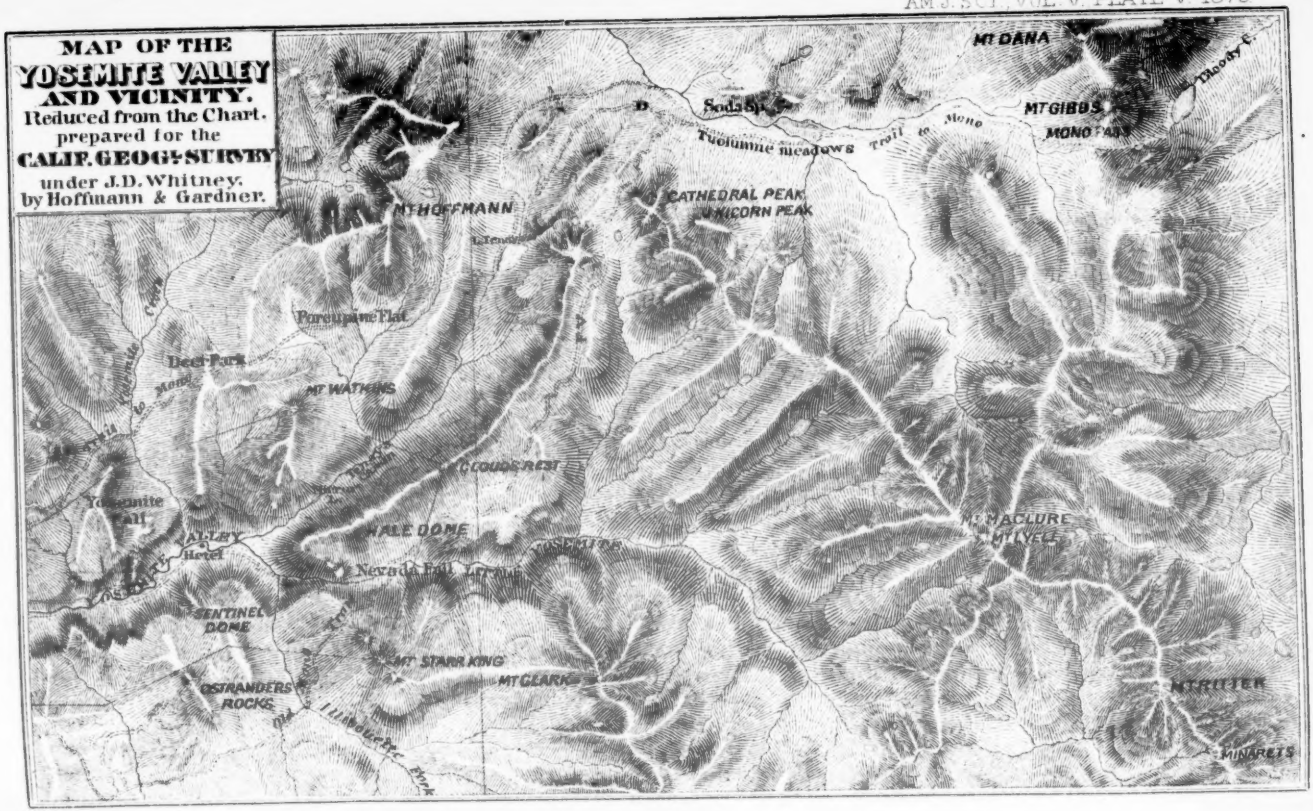


Published by Cornard, New Haven, Ct.

PLATE II. SOLAR SPOTS, MAGNETIC DECLINATION & AURORAL DISPLAYS.


NUMBER OF AURORAS OBSERVED EACH YEAR
MEAN DAILY RANGE OF THE MAGNETIC DECLINATION
RELATIVE EXTENT OF BLACK SPOTS ON THE SURFACE OF THE SUN

Punderson & Crissey, New Haven, Ct.


MAP OF THE
YOSEMITE VALLEY
AND VICINITY.
Reduced from the Chart.
prepared for the
CALIF. GEOG'L SURVEY
under J.D. Whitney.
by Hoffmann & Gardner.
MT DANA
Soda Sp.
MT GIBBS
MONO PASS
Tuolumne meadows
Trail to Mono
CATHEDRAL PEAK
UNICORN PEAK
MT HOFFMANN
Pavemente Flat
Deer Park
MT WATKINS
CLOUDS REST
Yosemite Fall
HALF DOME
Nevada Fall
MT MACLURE
MT LYELL
SENTINEL DOME
MT STARR KING
MT CLARK
STRANDERS ROCKS
MT RITTER
MINARETS